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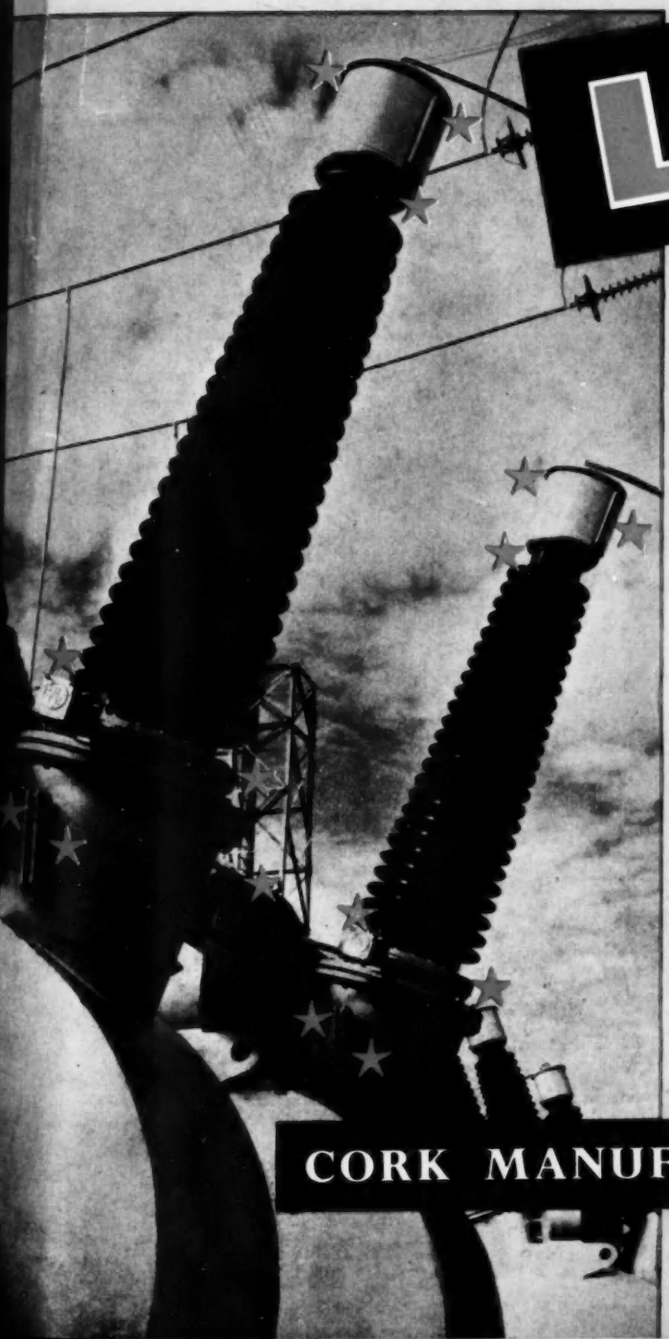

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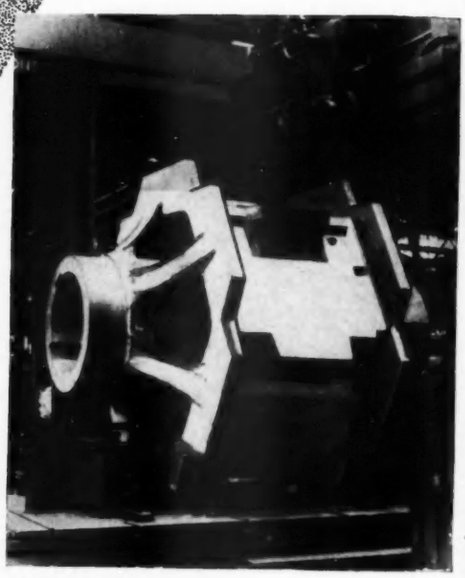

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No. 5480 **FEBRUARY 3, 1961** VOL. 211

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THE ENGINEER

No. 5480 FEBRUARY 3, 1961 Vol. 211

NEW CONCEPT OF TIDAL POWER

An interesting example of the interdependence of theory and practice is to be found in the story of the development work for the Rance tidal power scheme which has been going on in France over the past few years. One major result of all this work is an extremely versatile prime mover whose prototype is installed at St. Malo (no contract has yet been placed for the generating sets of the Rance Scheme itself) and is described in the article which concludes on pages 184-7. The perfection of this machine was essential if the entirely novel concept of tidal power utilisation put forward by Electricité de France's consultant, Monsieur Gibrat, was to be translated into practical achievement. The Rance scheme is now under construction, and will be the first tidal power site in the world to be utilised for power generation on the scale of contemporary power supply. The way in which partial independence from the rhythm of the tidal cycle has been achieved as a consequence of the very flexible method of operating the scheme was explained in outline in the first part of our article. It is this aspect of the scheme which is potentially of such importance, for it means that the economics of tidal power are thus radically changed and become far more attractive.

When the Severn barrage scheme was last seriously discussed in this country in 1949, its economic merit was based on the quantity of coal which it would save, since no firm power could be guaranteed. On this basis, it was economically competitive with other sources of power "under favourable conditions," it was stated. This may be compared with an economic analysis of the second French plan for electrical power which Monsieur Gibrat has published. Based on 8 per cent rate of interest, the aims of the plan (i.e. certain minimum figures for "guaranteed" and peak load installed capacities and total output) are achieved at minimum capital cost by thermal power alone, but at increased capital cost yet lower overall cost per unit generated by a combination of thermal power, hydro-electric power based on seasonal reservoirs, tidal power and run-of-river hydro-electric power. The analysis demonstrates that the place of tidal power in this combined system is potentially important in relation to the maximum economy of the plan as a whole, and competes with regulated hydro-electric output in economic attractiveness. Within the overall plan, each new scheme is defined by three figures, namely (*a*) peak load capacity, which is its output during the 300 peak hours of the winter quarter divided by 300, (*b*) "guaranteed" capacity, which is its output for the 1200 "full" hours of the same quarter divided by 1200, and (*c*) its annual output of energy. These figures are not invariable for the tidal scheme as they are for the other types of scheme, and can be varied according to the way in which the scheme is operated, one being increased to the detriment of the other two. The Severn barrage scheme would appear in principle to be a highly attractive investment when viewed in this way, especially since its pumping capacity would be so close to Berkeley, Hinkley Point and Oldbury nuclear stations, where power will be generated at very high load factors.

As far as the "bulb" sets themselves are concerned, they are claimed to give a 35 per cent economy in civil engineering costs as compared with conventional practice, and to increase the output of a tidal scheme by 40 to 45 per cent. The "unit" principle can be applied for maintenance by lifting the whole set out of its culvert, and replacing it, if necessary, in a fairly simple manner, which is important for an installation of thirty or forty sets. Turbine runaway is potentially more dangerous than with conventional vertical-shaft Kaplan sets, but this problem appears to be well understood. Nevertheless the bulb set is, without special measures, unsuitable for power stations where frequency regulation is required. There appears to be no reason, in principle, why even larger bulb sets than those we have described should not be built. On the other hand, extension of the size and scope of a tidal power project beyond that of the Rance scheme is still a debatable subject. A tentative proposal has been put forward for the bay of Iles-Chausey-Mont-Saint-Michel which envisages a reservoir formed by a "square" of sea, two sides enclosed by the Normandy coast, and the other two by a dam. Amongst the extensive researches needed for this proposal, hydraulic model investigations have introduced some novel problems, principally (*a*) whether Coriolis forces are significant and will have to be simulated in the model and (*b*) how much of the English Channel should be included in the model, for it is not known to what extent the proposal would react on the tides as they are now.

THE WORLD'S FUTURE TRANSPORT REQUIREMENTS

Sir Percy Hunting's Sempill Lecture to the Institution of Production Engineers on January 25 raised a number of important issues affecting recent developments in the air transport industry. One of the more fundamental points which he made concerns the operating costs of the "big jets". On the basis of the costs achieved by three of the largest American airlines during the first year of

operation of the Boeing "707", Sir Percy concluded that the direct cost per seat-mile of these aircraft has averaged out at a figure (2 cents) very similar to that of the previous "DC-4 Generation" types. It may be, however, that this judgment is over-pessimistic. Lord Douglas, in his 1957 Brancker Lecture to the Institute of Transport (quoted by Sir Percy Hunting), estimated that the total costs of turbine aircraft might be between 8 per cent lower for turbo-props and 16 per cent lower for jets at the aircrafts' mid-lives than they were during the first year of their operation. Figures published in the Annual Reports of British European Airways show that the specific operating costs of their V.701 "Viscounts" have, in fact, been reduced by some 20 per cent (in constant money values) between 1953 and 1958. If the improvement in operating economics likely during the aircraft's life is taken into account, it looks therefore — on the evidence quoted by Sir Percy — as if the jets may, in fact, prove to be at least 25 per cent cheaper to operate per seat-mile than the aircraft of the preceding generation. This is not a spectacular advance for vehicles which are perhaps a third larger, but it should be sufficient to enable the airlines to continue their expansion by further progressive reductions in fares. Also it should be noticed that the first generation jet transports have relatively unsophisticated single-flow engines with high specific fuel consumptions. The next change is clearly to more advanced by-pass and ducted-fan designs which will offer important improvements, and further advances which will result from the inevitable "stretching" of later versions of the successful jet transports should result in a continued further progression to lower operating costs. Incidentally, referring to Lord Douglas's lecture in this context, Sir Percy points out that the chairman of B.E.A. concluded in 1957 that the jets might prove to be 10 per cent more expensive than equivalent turbo-props. However, we must remember that Lord Douglas was comparing like with like and the fact of the matter is that there are no turbo-props in service to-day which are comparable with the much larger "big jets". In addition, dual-flow engine developments have revealed their full promise only during the past two or three years and were not allowed for in the 1957 comparison.

In the discussion which followed the Lecture, Mr. Peter Masefield challenged another of Sir Percy's contentions, that combination of the engineering bases of the two nationalised Corporations would give important economies. It does, indeed, seem arguable whether such a joining-together would, in fact, give the economics which Sir Percy hopes for on the basis of shipping experience. Where separate types of aircraft are operated on entirely different kinds of network, the practical obstacles to economic integration are likely to be very great. It is perhaps significant that two of the very few effective engineering arrangements between airlines in Europe provide evidence in support of this view. B.E.A. has effectively combined its own "Comet" maintenance with that of Olympic Airways where the aircraft are operating on similar types of services, while S.A.S. and Swissair, in their operating agreement, have been careful to centralise the maintenance of their joint "Caravelles" in the hands of S.A.S. while all that of the Convair jets is to be with Swissair. It is true that B.E.A. and B.O.A.C. have a common type in the "Comet", but this is an interim aircraft so far as B.E.A. is concerned. It is not difficult to see that the entirely different operating patterns of the two airlines and B.E.A.'s anxiety to "learn about jets" with "Comets" before getting "Tridents" might add up — as it seems to have done — to a strong case for keeping the maintenance of this type separate also.

The lecturer also made a strong case for the Corporations' use of outside contractors to a greater extent because, he held, it would be cheaper. According to pronouncements in B.E.A.'s Annual Reports, at least one Corporation holds precisely the opposite view and is bringing in its own outside contracts because it finds that it can do the work more cheaply itself — not wholly surprisingly even though it may be contrary to shipping experience. There is, in fact, plenty of evidence in the air transport industry all over the world that the essence of successful airline management is effective integration of conflicting maintenance and operational requirements, because the time element is highly critical to the running of an airline. Sub-contractors cannot be expected to show the same zeal as the operator himself in producing aircraft or their components at precisely the times they are needed to integrate with operational requirements. The extra cost of the looser integrations and the larger standby cover or spares floats needed to make the use of sub-contractors feasible is, in fact, likely to counter-balance any savings in cost—even assuming that the sub-contractor will be cheaper. Sir Percy's advocacy of "packing-in" the passengers in order to reduce seat-mile costs was commented on (not always favourably) by speakers in the discussion. The fact is, however, that reduction in space per passenger has been one of the most effective methods adopted by the airlines since the war to reduce their specific costs. There is reason to assume that this trend will continue, although whether it will proceed as rapidly or as far as Sir Percy advocates with his "standing room only" will rest as much with the licensing authorities as with what passengers are prepared to accept.

TECHNICAL INNOVATION

Under the Act by which it was set up, the National Research Development Corporation, whose Report for the year ending June 30, 1960, is noticed elsewhere in this issue, is required to manage its affairs so that "the return to them for their activities shall be sufficient to meet their outgoings on revenue account taking one year with another." Fortunately Parliament, exhibiting, as it often does, real wisdom, left open a loophole for the Corporation to run at a financial loss so long as there was a national gain. The words quoted have the qualification " in so far as can be done consistently with the fulfilment of their purposes." In fact, while there has been a steady increase in income received for royalties, sales of patent rights, &c. — tending to prove the value of the Corporation's work — there has also been a steady increase in outgoings and over the eleven years of its life nearly £3,000,000 have been advanced to the Corporation by the Board of Trade.

The work of the Corporation covers fields which extend well beyond the boundaries of engineering alone. But a perusal of the many engineering projects which it is supporting in one way or another strongly suggests how valuable the Corporation has proved to be. Amongst interesting projects which the Corporation has supported financially are those for the development of "Hovercraft" and of "Dracone" flexible barges, the latter the subject of a lecture to the Institution of Mechanical Engineers which we abstract in this issue. Both are examples of projects which have come close to the stage of profitable exploitation. Longer-term work in-

cludes research into the possibilities of fuel cells and into the practicability of stabilising ships in pitching. From time to time, of course, the Corporation supports researches or development work which prove abortive. It thus lays itself open to the criticism of those, with excellent hindsight, who hold that the work should never have been supported at all; and, of course, when it is stopped, of those who continue to maintain that it should have been pressed further! That is an occupational hazard; for the Corporation would not be doing the job it was set up to do if it took no risks. Indeed it needs to take rather more risks than many industrial firms would take, if only because one of its purposes is to guide and propel projects through the awkward and expensive stage between conception plus model or laboratory scale trials, which show no more than "promise", to the construction of full-scale prototypes which can demonstrate fully what the real capabilities are. It is, of course, as that latter stage is approached that industrial firms become really interested, so that licences can be granted or patent rights be sold. It is less well appreciated industrially, that the Corporation can help to finance projects originating within industry as well as those coming from universities, research bodies and private inventors.

In concluding his lecture on "The Early Development of the Dracone Flexible Barge" on Wednesday of last week Professor Hawthorne truthfully remarked: "In the last analysis the most important ingredients of all engineering projects are the imponderables of enterprise and imagination at all levels, without which the project cannot live." But, of course, an inventor may have enterprise and imagination and still be unable to interest others in his invention; to raise sufficient money to carry the project beyond the laboratory stage; or to get essential researches done. There the N.R.D.C. can help, as it did, indeed, help with the development of "Dracones." But something more than the help that organisation can give may be wanted. Professor Hawthorne remarked of his own lecture, "It is a case history of technical innovation. We need more studies of innovation in order to analyse the processes of design and development, to examine the interdependence of invention, analysis, technical and manufacturing skill, management and finance, all of which have essential roles to play in innovation." A part of the lecture which we do not reprint brought out his point clearly by showing that at intervals progress was delayed by technical, financial and other difficulties. How many sound ideas, we wonder, have never attained deserved success — or have taken long to do so — merely because the processes of innovation are ill understood?

CO-OPERATION IN EXPORTING

Last week there was an encouraging sign that the many exhortations to export more (which almost daily, it seems, are directed at industry) have not all gone unheeded. An announcement was made by the British Electrical and Allied Manufacturers' Association that at a meeting of over 130 export managers and senior executives of the electrical industry, a suggestion was welcomed that the association should make immediate arrangements to put firms in touch with makers of complementary equipment with a view to joint sales efforts, joint market research and collective exhibitions overseas. The advantages of pooling resources in the more competitive markets, bearing in mind the high cost of maintaining fully trained and experienced sales engineers abroad, was pointed out, and there was also a suggestion of sending to overseas territories small teams representing groups of manufacturers.

We venture to suggest that there may be many more manufacturing and trade associations in this country, which, because of their intimate knowledge of the firms and the trade they represent, could render both their members and the national economy a valuable service by emulating the example of the British Electrical and Allied Manufacturers' Association. Who better than they could co-ordinate the efforts of small member firms which are unable on their own behalf to investigate the challenge of overseas markets; and might not it be found, as it was with members of BEAMA, that larger firms, already well established in overseas markets, were willing to share their existing oversea facilities with smaller firms, and to make their experience available for others to learn from?

A topical example of the kind of service that can be helpful to smaller manufacturers is the *Export Guide* published quarterly by the Economic and Marketing Research Unit of The General Electric Company, Ltd. It is by no means a new publication, having just celebrated its fourth anniversary with the appearance, last month, of the eighteenth issue. This document, which is briefly reviewed on page 182, gives a factual record in graphic form of current trends in the exports of thirty-six categories of manufactured goods to thirty-four of Great Britain's main overseas markets. In addition it contains a number of general indices reflecting changes in the economic activity and trading prospects in each of these markets. It provides much of the market research information that a prospective exporter would need as the starting point of his effort. Here is one way in which the resources of a very large organisation can assist its smaller contemporaries.

The Engineer—100 Years Ago (FEBRUARY 1, 1861)

"BRAY'S TRACTION ENGINES"

"It having been in contemplation for some time past by the Lords of the Admiralty to supersede, in a great measure, the employment of horses in Her Majesty's dockyards by the use of Bray's steam-traction engines, some important improvements have been suggested in their manufacture, which are now being carried out in the construction of an engine on the improved system, to replace the one delivered by the company for the permanent service of the dockyard at Woolwich. The power of the new engine will be greater than that of the former ones, the area of the cylinders being nearly double. The framing will also differ, and will be somewhat similar to that of a railway locomotive, and an outside bearing is provided, which will considerably strengthen the wheels and prevent their laminating. The engines will be mounted on springs and the boiler suspended on trunnions to insure its being on a level in ascending and descending uneven ground, and the steam will be superheated to prevent priming. The engines on the old principle have been engaged for some days past in removing the Warrior's engines and machinery from Messrs. Penn's factory at Greenwich, and, notwithstanding the extremely varied state of the weather and the roads, they have succeeded admirably. On Wednesday the intermediate shaft was removed for the Warrior's engines, weighing 40 tons, with the truck."

The Dracone Flexible Barge

By W. R. HAWTHORNE, C.B.E., Sc.D., F.R.S.

The Thirty-third Thomas Lowe Gray Lecture was presented at the Institution of Mechanical Engineers on Wednesday of last week, January 25. We here reprint part of it. The "Dracone" barge is a long flexible tube with tapering ends which is designed to carry oil and other liquids lighter than water. Its skin is made of a woven nylon fabric proofed with oil—and weather-resisting rubbers. An illustrated description of such a barge appeared in our issue of September 26, 1958. Dracones have already been used for the commercial distribution of petrol, diesel oils, aviation and other grades of kerosene. They have been filled with crude oil and fresh water. They have carried 1,250,000 gallons of light oils and kerosene from Fawley to the Isle of Wight. There are three kinds of problems associated with engineering innovation. First there are technical problems, in this case in the fields of hydrodynamics, structures, textiles, plastics, petroleum engineering and shipping. Secondly, there are the managerial problems of planning and organising the research and development work. Finally there are the problems of promotion; of finding and maintaining the financial support for the development, and of discovering the commercial possibilities. The lecture was chiefly concerned with the technical aspects of the development of Dracones, but contained some account of the other aspects. Here we print from the lecture an account of some of the theoretical and experimental work and of the design work.

Inception

THE Dracone project was born in two casual conversations on November 23, 1956. During the first of these I discussed with Mr. J. C. S. Shaw the possibility of using a flexible plastic tube—a proofed fabric for instance—as an oil tanker. At luncheon I mentioned the idea to Sir Geoffrey Taylor whose favourable response and references to some earlier work for another purpose persuaded me to spend the afternoon examining it. A suitable target seemed to be a vessel of 10,000 tons capacity—anything smaller would be uneconomic for ocean transport. The strength of available materials had also to be considered. The greater the diameter of the vessel the greater the strength of material required. Too long a vessel would have a high surface/volume ratio and might be awkward to tow and berth. I thought that the length should not be more than 600ft, that is, that of a large ship. Given this length, the diameter necessary for a vessel holding 10,000 tons of crude oil of 0·85 specific gravity is about 30ft. The skin would have to withstand the stress required to prevent the oil spreading over the water, as well as the towing stresses.

By Monday, November 26, Shaw and I had written a short note presenting "A suggestion for a crude method of transporting oil by sea which might be attractive in the present (Suez) crisis." The proposed vessel was to be made of a fabric such as canvas or nylon impregnated with a plastic, so that it would be sufficiently flexible to be folded up. We estimated that at 10 knots the maximum resistance in calm water would be 12 tons which would give a steady longitudinal stress in the tube of 24 lb per inch of circumference. The static stresses in the tube, which would be filled with oil excluding all air, would depend on the amount of oil pumped in. We estimated that if the vessel was only 75 per cent full, the hoop tension would be 85 lb per inch. The note went on to say that the ultimate strength of a single layer of heavy canvas is of the order of 350 lb per inch, but materials of considerably higher strength are available, for example nylon, and that wave stresses are not likely to be as severe as with a rigid structure. Suggestions were made for strengthening the nose and reducing the snatch on the towing cable.

[The lecturer next outlined the early and subsequent history of the project. A number of Dracone barges have been made. Dimensions of typical barges are given in Fig. 1 and Table I and summaries of trials and operations in Table II.]

Theoretical and Experimental Research

As it is not possible to give a full account of all the theoretical and experimental work which has been undertaken, I have selected for full discussion two items, namely the static stresses and shapes of liquid-filled tubes both land-based and floating, and the problem of directional stability or snaking under tow. The work on resistance and on internal surging of the cargo has been summarised. Reference to the snatching of tow-ropes in waves is given in the section on operational techniques.

The Stresses and Shape of Static Liquid-filled Tubes.—The calculation of the static stresses in a long fabric tube filled with liquid and floating in water or lying on flat ground is given in detail in an Appendix to the lecture (not reprinted here). It is based on the condition of equilibrium for which the hoop tension in the skin is uniform about the circumference and is equal to the product of the pressure difference across the skin and its radius of curvature. This simple condition assumes that there is no friction and that the skin is weightless and has no rigidity. As a result of hydrostatic pressure, the pressure difference across the skin varies with height and hence the skin curvature is not uniform. For a tube lying on flat ground the pressure difference increases linearly from top to bottom, Fig. 2. For a tube floating in water the internal pressure also increases linearly from top to bottom, but from the water level downwards the external pressure increases linearly with depth at a faster rate than the internal pressure because of the greater density of the external fluid. Hence the pressure difference across the skin is a maximum at the water level. From the condition of equilibrium the skin curvature must also be a maximum at the water level.

Fig. 2 shows typical cross sections of the land-based and floating tubes, whose length is assumed to be great. In a portion of the tube of unit length there is a hoop tension T, which is uniform about the circumference.

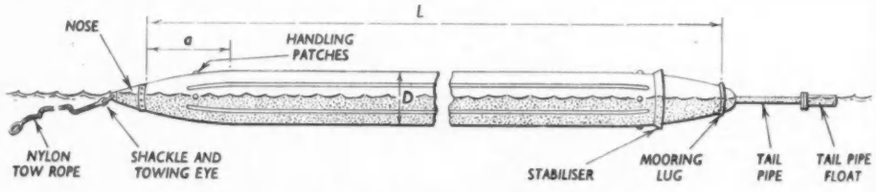


Fig. 1—Dimensions of typical Dracone models and barges

TABLE I

Type	D, ft	L, ft	a, ft	Maximum design capacity, gallons	Approximate weight empty, tons	November, 1960, Number completed
"Draconella"	3	67	11	2,800	—	1
"Draconeel"	1	44	3·3	240	—	1
D.1	4·8	100	17	9,820	1·15	16
F.1	7·0	137	21·8	28,820	2·5	1
K.1	10·2	206·5	35·9	90,300	6·5	1
B.1	4·0	68·2	12	4,585	0·5	—

The condition of equilibrium then gives the following equations :

(*a*) For the land-based vessel,

$$T\frac{d\theta}{ds}=\rho y \quad . \quad . \quad . \quad . \quad (1)$$

(*b*) For the floating vessel, for

$$y<y_w$$

$$T\frac{d\theta}{ds}=\rho y \quad . \quad . \quad . \quad . \quad (2a)$$

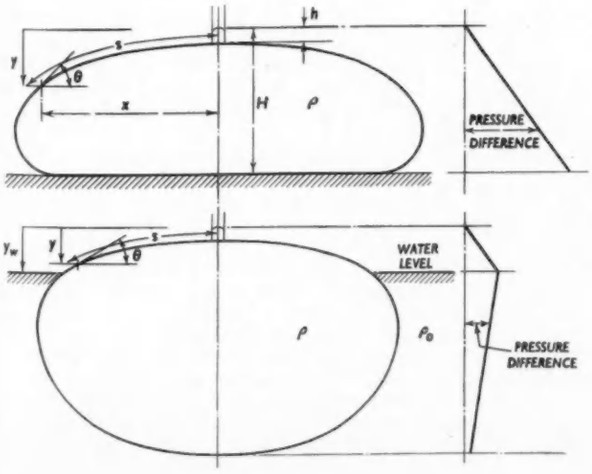
for

$$y>y_w$$

$$T\frac{d\theta}{ds}=\rho y-\rho_0(y-y_w) \quad . \quad . \quad (2b)$$

TABLE II—*Summary of Trials and Operations with Dracone Barges*

Dracone	Date of water test	Summary of history
D.1 ...	August 3, 1958	Continuously on trial at Southampton. First deliveries of kerosene to Isle of Wight. One wooden end replaced with steel end. Porpoising trials carrying fresh water.
D.2 ...	January 4, 1959	Sent to John Holt, Nigeria for one year. Carried diesel oil and kerosene. Transported cargo from Warri to Onitsha with all African crew. Returned to United Kingdom, fitted with new stabiliser for trials at Southampton.
D.3 ...	February 21, 1959	Sent to Shell-BP (Nigeria), Ltd. Used for carrying diesel oil in Niger delta. Has completed at least 5000 miles. Pontoon and reel used for return to base. Fitted with crude rope ring as stabiliser.
D.4 ...	April 18, 1959	Sea trials with kerosene. Crossed North Sea from Tees to Flushing and back in 9ft waves. Delivered kerosene from Fawley to Newport and AVTUR to Jersey. Sent to Australia, November, 1960.
D.5 ...	June 7, 1959	Used for diesel oil deliveries to Newport. Sent to Portuguese Guiné, West Africa, November, 1960.
D.6 ...	September 12, 1959	Delivered to Royal Engineers. Trials with kerosene at Southampton, Milford Haven, towed to Chatham and back from Southampton. Test with petrol on land at high stress for several months.
D.7 ...	October 24, 1959	Sent to Reynell Transport, Borneo. Towed 330 miles along coast of Sarawak in 8ft waves. Now on trial in Indonesia.
D.8 ...	December 5, 1959	On trial at Southampton. Spare for Fawley–Newport deliveries. Trials with petrol in North Devon.
D.9 ...	January 9, 1960	Demonstrated in the Thames, in New York and Oslo. Sent to Portuguese Guiné, November, 1960.
D.10 ...	March 12, 1960	Sent to Malaya. Towed along coast. Delivered diesel oil 550 miles from Singapore to Rejang River, Sarawak (towed by 1700-ton vessel).
D.11 ...	April 23, 1960	Sent to Malaya for transporting palm oil.
D.12 ...	June 4, 1960	Demonstrated in Toronto and Montreal. Delivers kerosene, diesel oil and petrol in Bay of Fundy from St. Johns to Grand Manan Island ; in waves up to 12ft high.
D.13 ...	July 9, 1960	Sent to Japan.
D.14 ...	September 3, 1960	Sent to Kiel for German Navy.
D.15 ...	October 8, 1960	Sent to Kiel for German Navy.
D.16 ...	November, 1960	Sent to Montserrat, West Indies.
F.1 ...	November 25, 1960	On trial at Southampton, for despatch to R.A.F.
K.1 ...	August 31, 1960	On trial at Southampton first with fresh water. Demonstrated at Chatham. Has been towed at 11 knots and in 8ft waves, carrying 350 tons of kerosene.



Showing pressure difference across skin and nomenclature used in theoretical analysis.

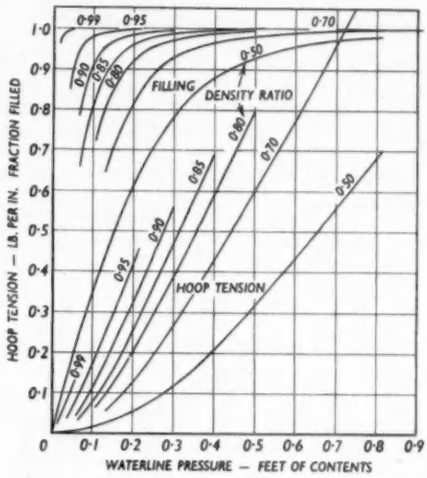
Fig. 2—Cross-sections of land-based and floating tubes

where ρ and ρ_0 are the densities of the internal and external fluids respectively.

The method of solution of equations (1) and (2) is described in the Appendix and numerical results are given in tables included in the Appendix.

The theoretical results for the shape of the land-based tube were confirmed by measurements on a polythene tube of 1ft diameter filled with water. Further confirmation of the theory has been obtained during the factory water tests of large Dracones.

For a floating tube the fraction filled, defined as the volume of tube occupied by liquid divided by the volume occupied when the tube has a circular cross section, is plotted in Fig. 3 against the water-line pressure difference for various ratios of cargo density to water density. Fig. 3, which is drawn for a tube of 1ft in diameter, also shows the hoop tension, which varies as the square of the diameter. Measurements made during the filling of various models showed satisfactory agreement with the theoretical curves. It is evident that the stresses in floating tubes are low up to fillings above 0·9. For instance, at 0·9 filling the value for hoop tension obtained from Fig. 2 is 0·167 lb per inch for a density ratio of 0·8. The hoop tension in a vessel 75ft in diameter is therefore equal to $0{\cdot}167\times(75)^2=940$ lb per inch. A

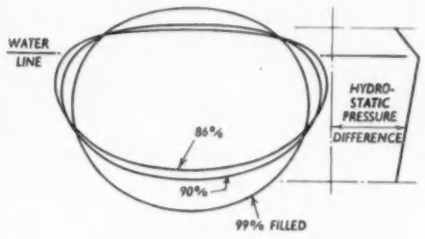


Tube diameter, 1ft. For other tube diameters multiply water-line pressure by diameter and hoop tension by (diameter)².

Fig. 3—Fraction filled and hoop tension (lb/in) *versus* water line pressure (ft of cargo above water line) for various ratios of cargo density to water density

floating vessel of this diameter and 1200ft long would hold 100,000 tons of oil.

The variation in shape with filling is shown in Fig. 4. The maximum beam is always below water level when the density ratio is

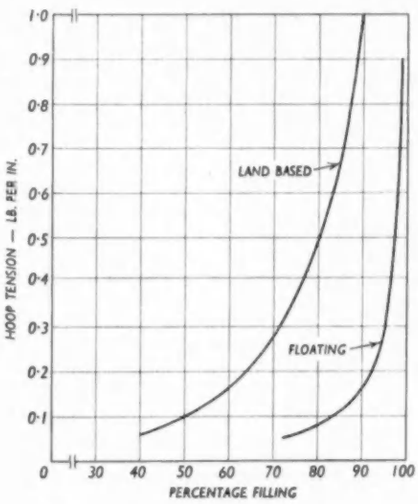


Cargo density = 0·85 + water density.

Fig. 4—Shapes of a floating tube for various percentage fillings

greater than 0·5, and the draught can be varied over a considerable range.

The land-based and floating vessels are compared in Fig. 5, which relates the percentage filling to the hoop tension for a liquid of 0·8 specific gravity. The advantage of the floating vessel is clear ; for the same hoop tension there is a marked increase in capacity. The curves are also useful for predicting the increase in tension when a floating vessel is stranded.



Density of contents = 0·8 + water density

Fig. 5—Comparison between hoop-tensions for land-based and floating tube of 1ft diameter

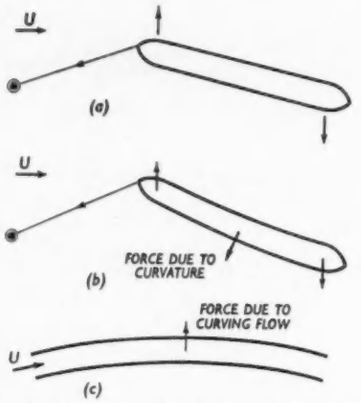
The Snaking Problem.—The theory of the directional stability of ships under tow (Strandhagen, Schoenherr, Kobayashi)[1] is similar to the theory of the yawing of an airship moored to a mast (Durand).[2] The tendency to yaw depends on the derivatives of the aerodynamic lateral forces and yawing moments with respect to angle of yaw and rate of rotation. When yawed in a wind a long slender body of revolution experiences lateral forces on its nose and tail which, as shown in Fig. 6(*a*), tend to increase the angle of yaw.

To achieve directional stability for a ship under tow it is necessary to fulfil the following conditions :

(1) The point of attachment of the towline should be located forward of both the centre of gravity and the centre of pressure of the static lateral force.

(2) The ship should be dynamically stable when moving untowed.

(3) When condition (2) is not fulfilled, it is possible to achieve directional stability either



(*a*) Solid body. (*b*) Flexible body. (*c*) Flexible pipe containing a flowing fluid.

Fig. 6—Lateral forces on yawing bodies of revolution under tow and on a bent flexible pipe

with a long enough or short enough tow-line. The critical lengths depend on the degree of the dynamical instability.

These criteria are not always fulfilled with rigid barges and were not fulfilled with large airships. Even a small fin or extra drag improves the behaviour of a directionally unstable, towed rigid vessel. The undamped oscillations are of slow period and often small. As the criterion for directional stability depends on the values of the aerodynamic derivatives, the speed of towing has no direct effect, and yawing of an unstabilised body will occur at all speeds.

If the body is flexible, another hydrodynamic force arises owing to the fact that a bent body in a flow experiences a force tending to bend it further, Fig. 6(*b*). This force is analogous to that on a cambered aerofoil which acts to increase the camber. The hydrodynamic force is opposed by the elastic forces in the skin. A similar phenomenon occurs when a liquid flows inside an elastic pipe. If the pipe is slightly curved, Fig. 6(*c*), the centrifugal force of the liquid acts to increase the curvature while the elastic forces in the pipe wall act to restrain it. There is clearly a velocity of flow above which the hydrodynamic force overcomes the elastic restraint.

A solution of the problem of the stability of a towed flexible tube based on slender body theory is given in the Appendix. There is a critical speed of towing, above which the tube is unstable in flexure. The value of the critical speed U for a streamlined body with no stabilising devices is given approximately by

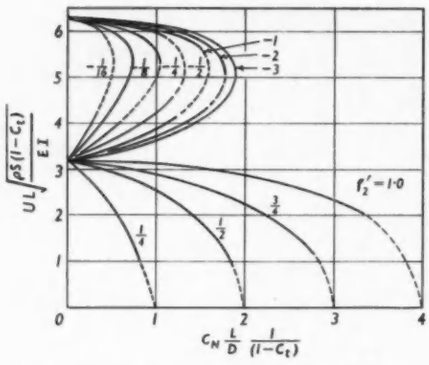
$$UL\sqrt{\frac{\rho S(1-C_t)}{EI}}=\pi$$

where L is the length of the body, S its maximum cross-sectional area, E the elastic modulus of the skin, I the moment inertia of the skin in flexure ($=\pi r^3 t$, where r is the radius of the tube and t its wall thickness), C_t is a drag coefficient and ρ is the density of the fluid. Theory and experiment are compared in Table III.

TABLE III—*Values of the Critical Snaking Parameter for Dracones Without Stabilisers.*

Description of Dracone	Length, ft	Critical snaking speed, ft/sec	$UL\sqrt{\frac{\rho S(1-C_t)}{EI}}$
9in diameter model No. 8	15·7	3·8	2·8
9in diameter model No. 12	29	2·3	3·2
"Draconeel"	44	2·0	3·3
"Draconella"	67	4·8	3·0
D.1	100	5·9	3·0

The full solution of the problem, Fig. 7, contains two variables f_2' and C_N'. The first, f_2', is a coefficient which allows for the effects



U is Critical snaking speed ; L Length ; ρ Water density ; S Submerged cross-sectional area; C_t external longitudinal load coefficient ; E Young's modulus for skin material ; I Moment of inertia of skin about vertical axis ; C_N' Lateral body force coefficient ; D Equivalent skin diameter or draught.

Fig. 7—Theory of snaking stability : critical speed parameter *versus* body lateral-force parameter for different tail lateral-force coefficients

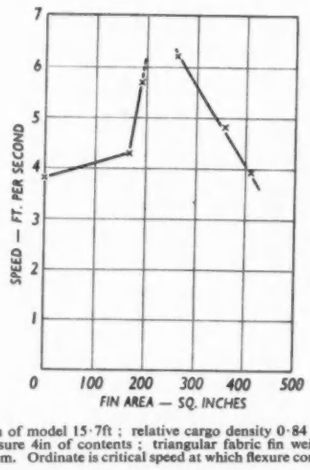
of viscosity, wave resistance, fins or other stabilising devices on the lateral forces developed at the tail. The second, C_N', is a coefficient which allows for lateral forces developed along the length of the tube by viscous and wave-making resistance. The critical speed for snaking is determined by the point of intersection of the ordinate with the appropriate value of

$$\left(C_N'\frac{L}{D}\frac{1}{1-C_t}\right)$$

and the curve with the appropriate value of f_2'. When the ordinate does not cut the f_2' curve, there is no critical velocity and the tube is stable at all speeds. For a clean, streamlined tail with no stabilisers the appropriate value of f_2' is approximately unity. The addition of a fin reduces the value of f_2' and, initially, the critical speed. When f_2' is zero, and provided C_N' has a value greater than zero, the theory shows that the tube should tow stably at all speeds. When f_2' is less than zero, a critical speed again appears for low values of C_N'.

Efforts to reduce snaking were based on the assumption that C_N' was small and that f_2' should therefore be reduced to zero. Critical speeds measured on a model 9in diameter by 16ft long to which weighted triangular fabric fins of differing areas were attached are shown in Fig. 8. The curve shows that there is a fin area which greatly increases the critical speed for snaking. By the slender-body theory the fin requirements for $f_2'=0$ are

$$\tfrac{1}{2}\rho U^2 C_L A_f=\rho U^2 S$$



Length of model 15·7ft ; relative cargo density 0·84 ; waterline pressure 4in of contents ; triangular fabric fin weighted at the bottom. Ordinate is critical speed at which flexure commences

Fig. 8—Effect of fin area on directional snaking stability of towed 9in model

where C_L and A_f are the fin lift coefficient slope and area respectively. The experiments reported in Fig. 8 and many others on Dracones up to 5ft in diameter show that fin areas between two-and-a-half and three times the maximum cross-sectional area of the tube are required, corresponding to a fin lift-coefficient slope of about 0·6. These values are, of course, applicable only to suspended fabric fins of the triangular shape used in the experiments.

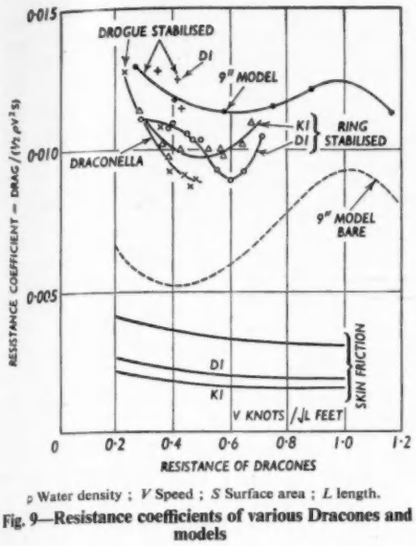
Attempts were made to increase the value of C_N' by hanging fins at points below the parallel portion of the tube. Two such triangular fins each of area 1·5 S enabled the tail fin to be reduced in area to 1·5 S. As soon as the belly fins were removed, snaking occurred.

Drogues prevented snaking, provided they were attached by several ropes of equal length to handling patches on the tapered tail. A drogue attached by a single line to the stern was ineffective.

Models with hemispherical tails could be towed without snaking, presumably because separation of the flow at the tail reduced the lateral force coefficient f_2' almost to zero. A similar effect was observed when the tail was squared off sharply with a wooden disc. In one experiment a ring was placed around the ellipsoidal tail of D.1 at a point where some reduction of cross section had occurred. The ring caused separation of the flow which was effective in stabilising the barge. The best location and dimensions of the ring were found by trial and error. Later a ring of triangular section was adopted to give a sharp corner for separation. In spite of its appreciably higher drag, the ring stabiliser has been preferred to a fin because it simplifies handling, and because in practice both fin and drogue were subject to damage by floating or under-water obstacles.

Other forms of ring stabiliser are being tried. The aim is to attain adequate stability and simplicity and at the same time a reduction in form drag, which may become important on larger Dracones. Below the critical speed for snaking the flexible vessel behaves like a solid vessel. The stabilisers required to prevent snaking will also prevent yawing at the subcritical speeds.

The Resistance or Drag of Towed Dracones.—In the history of naval architecture, interest in the resistance of floating bodies of revolution has been slight. Although early submarines had this shape, it was generally and properly regarded as unsatisfactory for a surface vessel. There was, therefore, no series of data on the resistance of similar solid vessels from which estimates of the resistance of Dracones could be obtained or which would serve as a useful comparison with our own measurements of the resistance of models which were made in towing tanks at the N.P.L. and Saunders Roe, Ltd. In most full-scale towing trials the resistance has been measured with a spring dynamometer placed between the towing hook or bollard and the tow rope. There were difficulties in measuring speed accurately, and we were greatly assisted by the Admiralty who lent us an accurate instrument. Some of the resistance measurements of stabilised Dracones ranging in diameter from 9in to 10ft are shown in Fig. 9, in which resistance coefficients based on the wetted area are plotted against the modified Froude number or Taylor quotient (V knots/$\sqrt{L}$ft). The large separation drag due to the stabilisers may be seen by comparing the curve for a drogue-stabilised 9in model with the curve for a 9in model without a stabiliser. Estimates of the component of resistance due to skin friction are also shown in Fig 9. At low speeds the largest component of resistance



ρ Water density ; V Speed ; S Surface area ; L length.

Fig. 9—Resistance coefficients of various Dracones and models

is due to the separation drag introduced by the stabiliser. At the higher speeds there is evidently some interference between wave making and separation which prevents the total resistance from increasing appreciably. The use of a stabiliser with a larger drag than usual accounts for the relatively large values of the resistance of the K.1 barge. The additional drag due to a stabilising fin was found to be less than 40 per cent of that due to a ring or drogue.

Some experiments were conducted on the effect of the nose shape, which showed that the drag of an asymmetrical upward sweeping nose was slightly less than that of a symmetrical nose. The difference was, however, only a negligible fraction of the total resistance of the stabilised Dracone.

As the pressure in the barge is reduced, the wetted surface is decreased but the resistance increases. The increase is not marked except at very low pressure when the nose tends to crinkle under the action of the external dynamic pressure.

Internal Surging of the Cargo.—Owing to the change of pressure with cross-sectional area of the tube, Figs. 3 and 4, a pressure pulse will travel from one end of the tube to the other. The phenonenon may be treated as a one-dimensional problem with the equation of motion

$$\frac{\partial V}{\partial t}+V\frac{\partial V}{\partial x}=-\frac{1}{\rho}\frac{\partial p}{\partial x} \quad . \quad . \quad . \quad (3)$$

and of continuity

$$\frac{\partial A}{\partial t}+\frac{\partial AV}{\partial x}=0 \quad . \quad . \quad . \quad . \quad (4)$$

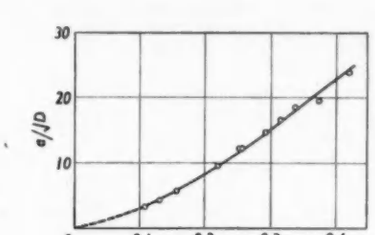
where A and V are the cross-sectional area and velocity of flow and p is the average pressure in the tube. If the disturbance is small so that $V(\partial V/\partial x)$ and $V(\partial A/\partial x)$ may be neglected, then the wave equation is obtained by noting that A is a function of p only and eliminating A from equations (3) and (4) :

$$\frac{\partial^2 V}{\partial t^2}=a^2\frac{\partial^2 V}{\partial x^2}$$

where the wave speed a is given by

$$a^2=\frac{A\,\mathrm{d}p}{\rho\,\mathrm{d}A}$$

From the curves of fraction filled against water-line pressure, Fig. 3, the variation of wave speed with initial conditions can be estimated. At low fillings $\mathrm{d}p/\mathrm{d}A$ is small, but it increases rapidly at the knee of the curve. Measurements of the wave speed for very small disturbances in a stationary floating tube are compared with theory in Fig. 10.



Relative density=0·8 ; a Speed, feet per second ; D Tube diameter, feet ; h Water-line pressure, feet of contents.
○ Experimental. ——— Theoretical.

Fig. 10—Speed of a small internal-pressure surge in a floating tube

If we assume that the tube follows the configuration of the external waves, then the equation of motion for small fluctuations becomes

$$\frac{\partial V}{\partial t}+\frac{1}{\rho}\frac{\partial p}{\partial x}+g\frac{\partial z}{\partial x}=0 \quad . \quad . \quad . \quad (5)$$

where z is the height of the tube or wave above its mean value. If we assume a simple external wave train of wave length λ and velocity, c, then

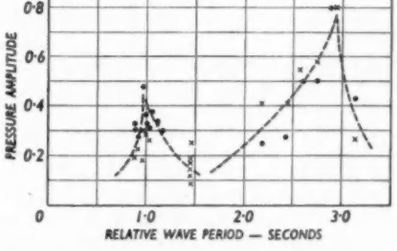
$$z=z_0\cos\frac{2\pi}{\lambda}(x-ct)$$

where z_0 is the amplitude of the external wave.

From equations (4) and (5) we obtain equation :

$$\frac{\partial^2 V}{\partial t^2}-a^2\frac{\partial^2 V}{\partial x^2}=gz_0c\left(\frac{2\pi}{\lambda}\right)^2\cos\frac{2\pi}{\lambda}(x-ct)$$

The boundary conditions at the ends of a tube of length L are $V=0$. The solution of this equation shows that there are numerous resonances depending on the values of L/λ and a/c. Efforts to pick up these resonances in tank trials were unsuccessful because the pressure surges are highly damped, but peak pressures seemed at times to appear when the period of encounter with the waves



Approximate natural periods of vibration of model as a free beam ; 1st mode=2·8 seconds ; 2nd mode=1 second.
● 3in wave height. × 6in wave height.
Pressures recorded as multiple of the wave height.

Fig. 11—Peak pressures in 9in model towed in regular waves

coincided with the period of vibration of the Dracone as a free floating beam, Fig. 11.

In the simple analysis given above, it is assumed that the external pressure in the surrounding fluid is unaffected by the motion in the tube. This is far from the case. As the pressure surge travels along the tube, wavelets can be seen in the surface of the surrounding water propagating from the disturbance. The effect of the pressure variations in the surrounding fluid is to alter the wave speed and to introduce damping. When the tube is moving through the surrounding fluid, the magnitude of these effects varies with the direction of the internal pressure surge.

The damping is so large that it has been found in practice that the reflected pressure wave at the tail diminishes rapidly. As the magnitude of the disturbance in the surrounding surface is affected by the change of cross-sectional area of the tube it is to be expected that the damping is greatest when $\mathrm{d}p/\mathrm{d}A$ is least, that is, at fillings below the knee of the curve in Fig. 3.

The fluctuations in internal pressure were measured on models, using a small capacity-type pressure pick-up. A range of wave heights up to four times the model diameter was covered, The magnitudes of the pressure peaks were found to be roughly proportional to the wave height and to depend largely on the value of the period of encounter with the waves. The pressure peaks diminished as the filling was decreased. The results from the tank trials indicated that a maximum pressure of twice the wave height was rarely exceeded, and in general the maxima were much lower. Measurements in D and K size barges at sea support this general conclusion.

*Design of D.*1.—In preparation for the design of a prototype 10,000 gallon barge, several shapes were considered. Barges of 5ft, 6ft and 7ft in diameter were estimated to be 100ft, 75ft and 50ft long, with material requirements of approximately 175, 150 and 125 square yards respectively. Only the first barge of 5ft diameter had the proportions of " Draconella," so that to explore the problems of towing shorter and fatter barges, a model 1ft diameter by 7ft long was built with the proportions of the 7ft diameter barge.

While we were considering the strength of the fabric skin required for each size, we found that some woven nylon fabric with a nominal strength of 1000 lb per inch in both warp and weft direction was available. Unfortunately, experiments had not proceeded far enough to give good quantitative results for the internal pressure surges experienced in waves, but the surges were expected to give excess pressures somewhat more than the wave height. As wave heights of up to 20ft are not uncommon, we realised that the internal pressures might reach large values. I was, therefore, forced to choose the 5ft diameter barge, both because it was safer and because it had the same proportions as " Draconella " with whose behaviour we were familiar. It later turned out that the 1ft diameter by 7ft long model tended to yaw and dive more than the models of 20/1 length/diameter ratio. The smaller diameter was also attractive because the reel could be smaller. As time has passed we have noticed that the barge with 20/1 proportions has other attractions. It kinks more readily when turning so that it easily tracks the towing vessel, and its proportions permit the use of long tapering ends. These ends increase the critical diving speeds, can be readily flattened when empty, and make fabrication from a few panels easier. The additional drag due to the proportions of 20/1 is negligible ; it is caused by skin friction on the larger surface area and is only a small proportion of the total, which is largely caused by wave and form drag.

Materials.—Our choice of nylon as the basic stress-bearing component of the barge skin was supported by Warburton Hall. Nylon yarn has a high tenacity and energy to rupture for a given weight. Although it is attacked by ultra-violet light, it is inert to cargoes such as hydrocarbon oils and to water. To simplify its proofing and construction, it was best used as a woven fabric of single thickness. The requirements for the weave were maximum tear resistance and resistance to penetration. To assist in obtaining good adhesion between the fabric and the coating some interstitial space was thought to be desirable.

Rubbers were chosen for the proofing

materials because of their great flexibility and because of the many years of experience which promised to reduce the problems in manipulation and coating. The coating had to be tough, abrasion and oil resistant, and having good adhesion to the fabric. In addition the inner coating had to have low permeability to the cargo and be able to maintain its properties over many years in hydrocarbon oils. The outer coating had to resist weathering and sunlight for several years in all parts of the world. It was decided to use different synthetic rubbers for the inner and outer coatings. A butadiene-acrylonitrile-base rubber was chosen for the inner coating and a chloroprene type for the outer coating. The choice was strongly affected by the good service which both types of rubber have already given in engineering use, for example, in petrol hoses.

To keep the weight low, a thin skin was desirable ; on the other hand a sufficient thickness of rubber was required on the outside to give good abrasion resistance and to protect the nylon against sunlight. The inner coating had to be thick enough to ensure sealing and to minimise the diffusion of light hydrocarbons through the wall, particularly in tropical conditions.

After some experiments a mock leno weave was chosen with a thickness of coating on each side not less than 0·050in, giving a total skin thickness of 0·125in. Although calculations showed that the longitudinal stresses in the central portion of the barge were less than the circumferential stresses, for the sake of simplicity the same strengths were specified in the warp and weft directions.

The immediate constructional problem arose because of the difficulty of jointing together widths of proofed fabric. Long lengths of proofed material could be readily manufactured, but their widths were limited by such factors as the width of calenders for proofing and by the tailoring difficulties in making non-developable surfaces out of flat panels at the tapered ends. In fact the width of the 1000 lb per inch nylon fabric in stock was 36in so that the minimum number of seams for a 5ft diameter barge was six, each of which ran longitudinally from nose to tail. Longitudinal seams were preferable to circumferential seams because, when the tube was under pressure, the longitudinal strain would be almost negligible. There would, therefore, be no stress concentration set up by differential expansion between the panel and the thicker and stiffer joint. With local circumferential stiffening, as on " Draconella," appreciable differential strains were both calculable and visible.

The problem of constructing the joint was considered in the light of experience of jointing light-weight proofed fabrics. In many applications, joints in such fabrics are made by cementing their overlapped edges with a rubber adhesive of either a hot or cold curing type. Warburton Hall[3] had shown that stuck overlapped seams suffer considerable deterioration in strength when continuously strained, particularly when exposed to petrol. The decay in joint strength of strip test specimens under constant tensile load and immersed in petrol containing 18 per cent by volume of an aromatic hydrocarbon is shown in Fig. 12. To prevent failure in six months under continuous stress, the loading has to be reduced to less than 20 per cent of its value for rupture after one minute. Nylon exhibits some loss of strength with time, but its long-term strength is still high, the stress-to-rupture in one year being about 70 per cent of the stress to rupture in one minute. Therefore, it was assumed that joints depending for their mechanical strength on the use of rubber adhesive alone would not be satisfactory for use in D.1.

Stuck joints in thinly proofed fabrics may be reinforced by stitching through the proofed fabric, but it was expected that sewing through the heavily proofed fabrics would be difficult. Therefore Warburton Hall and P. B. Cow, Ltd., developed a method for peeling back on both faces the rubber proofing after calendering and curing, so that a strip of bare nylon fabric a few inches wide was exposed. The fabrics were overlapped and locked together with a standard method of sewing. The peeled-back flaps of proofing were then replaced and sealed over the jointed fabric and the whole joint given more protection by sealing a wide, lightly reinforced outer cover strap over the joint on both sides.

Samples of the joint were made to study the effect of such variables as size and type of the sewing thread, pitch of the stitches and the number of lines of sewing. In this way joints were developed with a short-term tensile strength approaching the strength of the bare fabric. A schematic drawing of the joint finally used in the construction of D.1. is shown in Fig. 13.

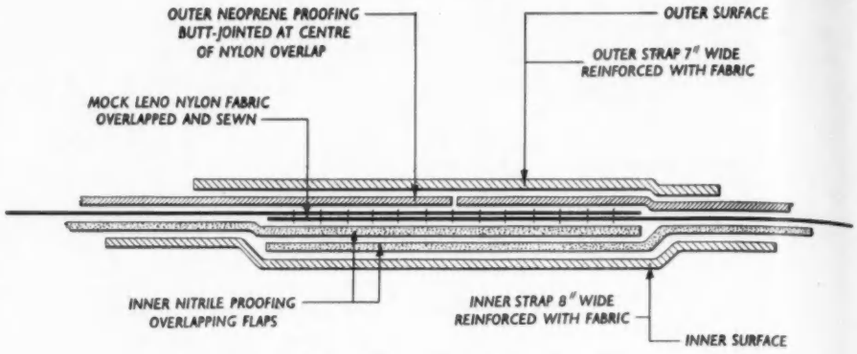

OUTER NEOPRENE PROOFING BUTT-JOINTED AT CENTRE OF NYLON OVERLAP
OUTER SURFACE
OUTER STRAP 7" WIDE REINFORCED WITH FABRIC
MOCK LENO NYLON FABRIC OVERLAPPED AND SEWN
INNER NITRILE PROOFING OVERLAPPING FLAPS
INNER STRAP 8" WIDE REINFORCED WITH FABRIC
INNER SURFACE

Fig. 13—Schematic diagram of the seam used on D.1

D.1 End-Pieces and Handling Patches.—A laminated hardwood was again chosen for the end-pieces, but some improvement on the " Draconella " design was needed to increase the strength of the attachment of the fabric to the wooden ring. The bare nylon fabric was doubled round a ¼in diameter galvanised steel ring and secured by sewing, Fig. 9, and the steel ring bore up against a shoulder in the wooden end-piece. At first it was thought that the inner layer of proofing could be securely cemented to the rubberised wood, but to guard against peeling and leakage, a steel Jubilee clip was used to grip the internal proofing and nylon fabric firmly to the wooden end-piece. Bolts passing through long holes in the end-piece were used at the nose to hold a blank flange of Tufnol and a towing attachment. At the tail, a steel flange with lugs for attaching stern ropes was inserted between a Tufnol flange and a self-sealing coupling.

Thimbles spliced in short lengths of rope, whose splayed ends were cemented between the skin of the barge and circular rubber patches, formed attachment points for ropes and boat hooks. Drogues, fins and rings were in turn lashed to these " ears."

Design of D.2.—The main difference between D.2 and D.1 was in the design of the end-pieces which were made of steel, and in each of which there was a manhole. The early introduction of a manhole was to some extent forced on us by the trouble which had been experienced in fitting the wooden end-pieces to D.1. A diagrammatic sketch of the welded fabrication forming the end-pieces is shown in Fig. 15. The nose and tail end-pieces were identical ; at the nose a towing attachment was bolted to the short, cylindrical steel skirt forming part of the end-piece, Fig. 15 ; at the tail supports for the tail-pipe hose were bolted to the skirt. Fairing and buoyancy pieces of foamed plastic, encased in fibre glass, were features of the design.

We were anxious to keep the weight low, in order to avoid putting undue loads on the fabric, particularly in waves. This consideration led to the choice of aluminium for the manhole cover to give stiffness and low weight. The choice of aluminium led in turn to problems in the choice of materials to avoid corrosion. The overriding consideration was that the metal parts attached permanently to the fabric of the barge should not corrode.

Minor modifications were made to the seams in order to improve their flexibility, and a slightly stronger fabric was woven by Stotts Ltd. for the barge.

Design of Later Dracones.—The design of D size barges was continually improved as operational experience was gained. The towing attachments were modified by using a cone which was sealed at its base and fitted

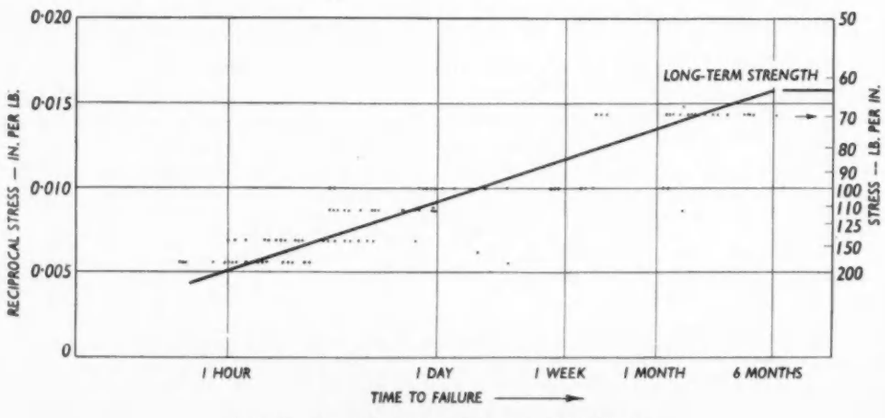


Fig. 12—Long-term strength of cemented joints [3]

with a removable plug which enabled the space within the cone to be either flooded or emptied, so that the buoyancy could be adjusted to facilitate the sinking of the nose. Modifications were also made at the tail. The self-sealing coupling was replaced by a length of suction hose which was blanked off at the end by a flange to which a float consisting of a short cylinder of foamed plastic was attached. The steel parts, except where rubberised, were galvanised by the hot-dip method. The aluminium manhole cover was replaced by a reinforced steel plate.

After some discussion of the problem of forming the tapering ends, four instead of six panels were used successfully on D.5. Further modifications were made to the seam construction to improve its flexibility and to simplify its manufacture.

In designing the K barge, we were limited by the width of the calenders used for proofing the panels to a width too small to enable the 10ft diameter shape to be formed of only six panels, and eight panels were used in its construction. Because of the increase in size more room for the manhole was available at the ends, and the end-piece which had to be stronger and larger, could be shortened to prevent an undue increase in weight.

By the time the F barge, Fig. 1, was designed a modified seam had been tested, which enabled four panels of width sufficient to give the required dimensions to be used.

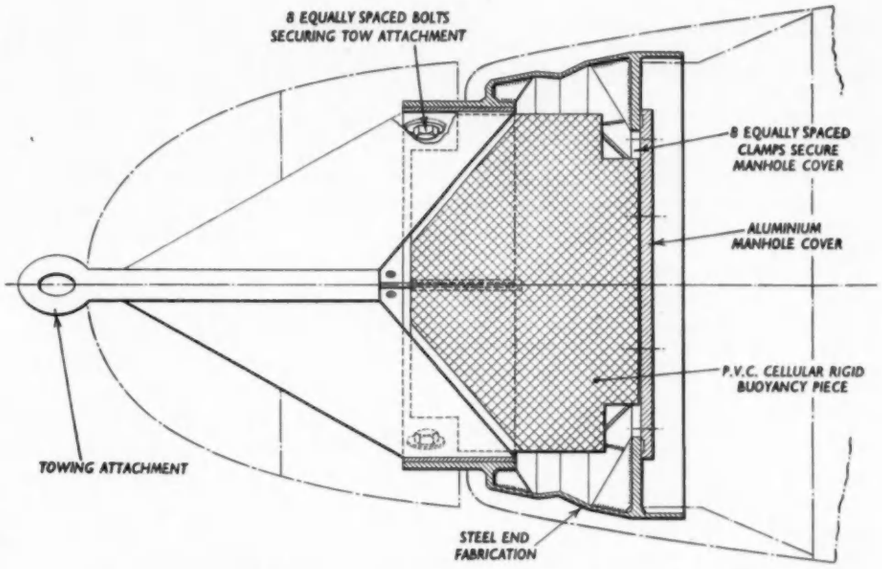

8 EQUALLY SPACED BOLTS SECURING TOW ATTACHMENT
8 EQUALLY SPACED CLAMPS SECURE MANHOLE COVER
ALUMINIUM MANHOLE COVER
P.V.C. CELLULAR RIGID BUOYANCY PIECE
TOWING ATTACHMENT
STEEL END FABRICATION

Fig. 15—Arrangement of D.2 nose showing manhole and cover, buoyancy pieces and tow bar

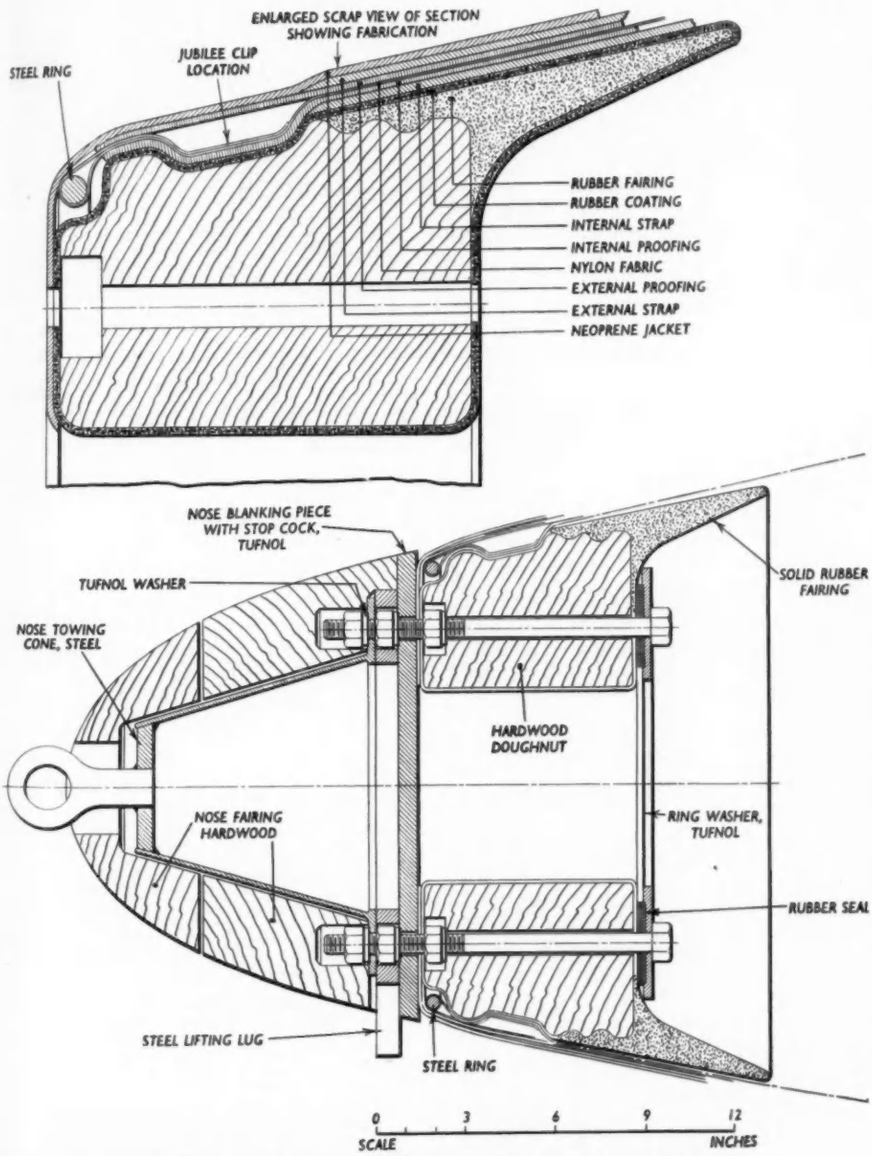


Fig. 14—Nose assembly for D.1, showing towing cone and buoyant fairings

Strength calculations for the end-pieces based on the assumption that they had to withstand both the maximum internal surge and the maximum tow-rope snatch at the same time showed that the D end-pieces could be adapted to the F size barge with only minor alterations.

Conclusion

This account of the development of flexible barges is not complete. Apart from obvious omissions, such as the analysis of the porpoising and internal-surging problems, results of tests on sewn seams and the development of improved end-pieces and stabilisers, I have not mentioned the work of a committee, under the chairmanship of Warburton Hall, which has been concentrating on the problems of proofed fabrics of high strength. Work on venting, on heating viscous oils, and on grain and other special cargoes has also not been discussed. I have made no reference to the ideas and work of others on flexible barges. In 1946 Scott[4] disclosed ideas for a non-rigid barge, but there is no record of their application. Since 1956 interest in flexible barges has developed, notably in Germany, and it is evident that their possibilities are being explored elsewhere.

The work described in this lecture is concentrated on the attempt to develop a vessel of proofed fabric to withstand the conditions of operation in both sheltered waters and at sea. More generally, the lecture describes an effort to use flexible materials of high strength for engineering structures. It is also a case history of technical innovation. We need more studies of innovation in order to analyse the processes of design and development, to examine the interdependence of invention, analysis, technical and manufacturing skill, management and finance, all of which have essential roles to play in innovation. In the last analysis, however, the most important ingredients of all engineering projects are the imponderables of enterprise and imagination at all levels, without which the project cannot live.

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Modernisation of Meadowbank Salt Mine

Meadowbank Mine, Cheshire, the only British producer of salt by underground mining, has been modernised to increase output and efficiency, and the salt is now mechanically handled right from the working faces to final loading for despatch.

SALT has been produced in Cheshire for centuries, and at one time much of it was obtained from the rock salt beds by underground mining. To-day by far the greater proportion of the salt extracted is pumped up as brine, which is evaporated in surface plant, the solid product then being processed to suit customers' requirements. Rock salt, however, is still produced at one mine, Meadowbank, near Winsford, by underground mining methods, to meet the needs of certain users, of which the principal ones are : municipal and other highway authorities, who use it for snow and ice clearance ; agriculture, where it is used for land treatment ; and some of the metallurgical industries, in which it plays its part as a flux.

Meadowbank mine was sunk about 1844, and worked for some time on a small scale, using hand mining methods. After various vicissitudes the mine became the property of Imperial Chemical Industries, Ltd., in 1937, and it is now operated by that company's Salt Division. Progressive modernisation and the sinking of a new shaft in 1941 to supplement the two existing small ones enabled output to be increased, but more recently it was decided to replan the underground workings, abandon the traditional narrow-gauge tramway used for transport, and equip the shaft with skips instead of cages. At the same time new handling equipment on the surface was to be installed. This work has now been completed, and the mine is now mechanised throughout.

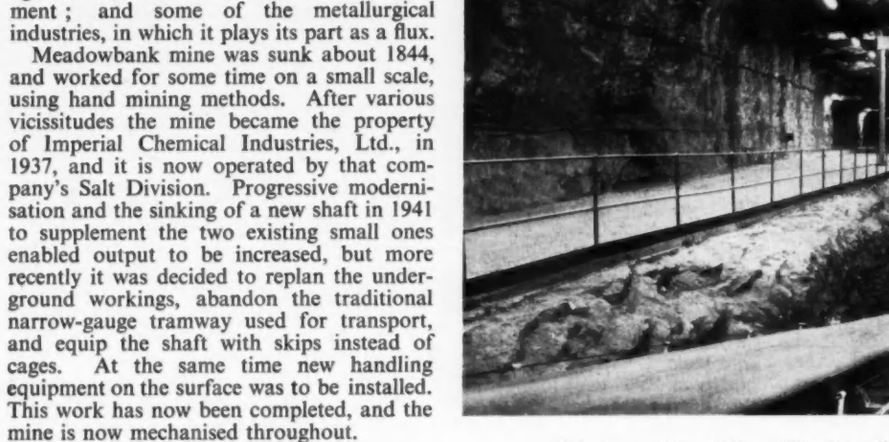
Rock salt is found in two thick beds at Meadowbank. One bed, the upper of the two, is no longer worked, but the main bed, 86ft thick and about 470ft below ground level, which contains very large reserves, is now being vigorously developed. The best quality rock salt lies in the lower 20ft of the bed, and this portion is worked on the pillar and stall system, leaving the remainder of the bed in the roof, which is very strong. As a result of the natural strength of the roof, large stalls 50ft wide, with 50ft square pillars, are possible, and access to the working faces of the stalls is excellent.

Shortwall chain machines are used to undercut the entire width of the stall face to a depth of 10ft, and electric drills, mounted on a self-propelled carriage, put down 10ft shot holes in a predetermined pattern above the undercut. The holes are then charged with explosive and the face is blasted down.

Run-of-mine salt from the face is loaded mechanically by crawler-mounted loaders of the gathering arm and conveyor pattern into Foden diesel dumpers carrying approximately 8-ton loads, which haul it to a primary crusher station near the shaft bottom. Here the run-of-mine salt is discharged into a gyratory primary crusher made by Pegson, Ltd., Coalville, which reduces it to —5in. It then passes to the handling plant which, from this point to the surface, was designed and built by Head Wrightson Stockton, Ltd., Stockton-on-Tees. The plant is designed to convey and hoist 138 tons of rock salt per hour, using 2½-ton skips in the largest of the three shafts, this throughput being based on a shaft utilisation of fifty-five winds per hour.

On leaving the primary crusher, the salt falls by gravity to a 42in wide belt conveyor, 188ft long, which lifts it to a transfer point and so to a second 42in conveyor, 147ft 9in long, and making an angle, in plan, of 105 deg. with the first. Both conveyors are of orthodox construction, with steel supporting structures, but with certain modifications to allow for the presence of salt. All the belt idlers have a vitreous enamel finish, and the tension screws are of stainless steel. Each conveyor is lubricated from a single point by Tecalemit " Line-o-matic " grease injection equipment.

Primary crushing station. This illustration shows well the spaciousness of the mine



Dumper discharging at primary crushing station

The second of the two conveyors discharges into a surge hopper, which is of 18 tons capacity, to allow for short breaks in conveyor loading while skip winding is in progress. Pressure pad switches are incorporated in the surge hopper sides to give high and low contents indication, which are electrically repeated by signal lights at the primary crusher hopper ; dumper drivers are thus shown if, for any reason, the surge hopper is full, and they can pause until the light is extinguished before dumping their loads. An apron feeder, 36in wide and 40ft 6in long draws, the salt from the surge hopper and discharges it to one of two 2½-ton measuring pockets. These pockets are also mounted on load rings, and immediately one pocket is full, an electric signal from the load rings sets in motion a hydraulic cylinder which operates the feed chute and so diverts the salt to the other pocket. If both pockets are full the apron feeder is cut out automatically.

For the greater part of its length the second belt conveyor runs horizontally, at a height of about 15ft above the mine floor level, and a travelling tripper is arranged to operate

over this part of the conveyor, to discharge salt to the side of the supporting structure when required. Space is available here for an 800-ton stock pile, and mining can thus continue when the winding shift has finished. Reclamation from the stock pile is by means of a Michigan tractor shovel, which discharges its load into the surge hopper.

Skip Winding

Bottom-discharging skips are used to hoist the salt in the shaft, the existing electric winder and headgear having been adapted to suit the new equipment. To obtain the greatest possible load capacity within the size limitations imposed by the winder and headgear, the skips are of aluminium alloy. Each skip is 17ft 6in long by 6ft 6in by 3ft 4in, and a deck is fitted over the top of the skip hopper to provide a man-winding cage on the top. Hinged doors in this deck give access to the hopper when salt winding is in progress. Below the skip, at the point where it is angled away to discharge its contents, an inspection platform is provided. In addition facilities are provided under the skip for suspending bulky equipment.

Hydraulically operated doors at the outlet of the measuring pockets are used, under manual control by the onsetter, to load the skips, which are discharged on arrival at the surface by a mechanical catch frame hydraulically operated and controlled by the banksman, which opens the bottom door of the skip. A self-contained hydraulic pumping set housed near the shaft bottom provides hydraulic power for operating the measuring pocket gates and also the feed chute to the pockets. Similar equipment at the surface provides the hydraulic power used there for skip door operation.

Salt discharged at the surface falls into a receiving hopper and thence, via an apron feeder, to a belt conveyor leading to a Pegson secondary crushing and screening plant. Here it is processed into two grades, $-\frac{1}{4}$in and pulverised, and taken by conveyor to a storage installation consisting of three silos, one of 250 tons and two of 50 tons capacity each. From this point the salt can be loaded in bulk to road or rail vehicles, or it can be packed in paper or hessian sacks. Alternatively, it can be passed to a large open-air stock pile, from which it is reclaimed as required by a Michigan power loader. It should be added that although rock salt would not, at first sight, be considered as suitable for stocking in the open, the rock salt produced by I.C.I. has, in fact, proved quite satisfactory when stored in this way. Under the influence of the weather a thin, fairly hard crust forms quickly on the pile, and this protects it effectively from the action of rain and moisture.

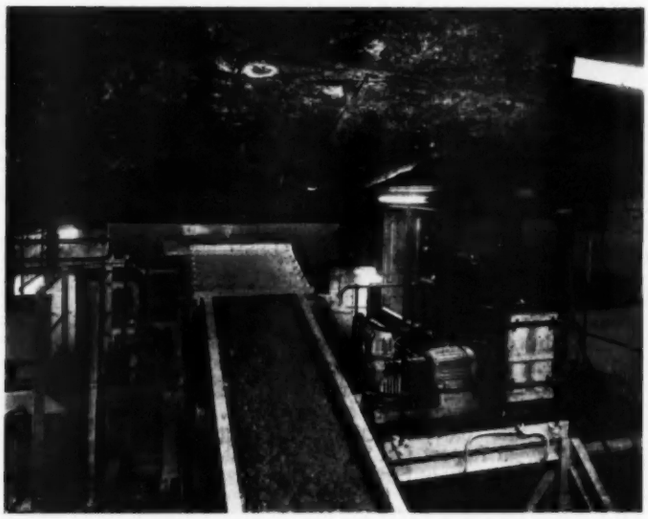
Operation

The main skip winding shaft is now used as the principal means of access to the mine, leaving the two older and smaller shafts to serve for emergency purposes and to deal with a certain amount of maintenance material winding. This means that men and materials are dealt with by the main skip shaft, as well as the hoisting of the entire mine output. Consequently the skip shaft utilisation is very high. Very comprehensive safety measures are incorporated in the complete layout, with interlocking throughout to prevent unsafe, or wrong sequence operation.

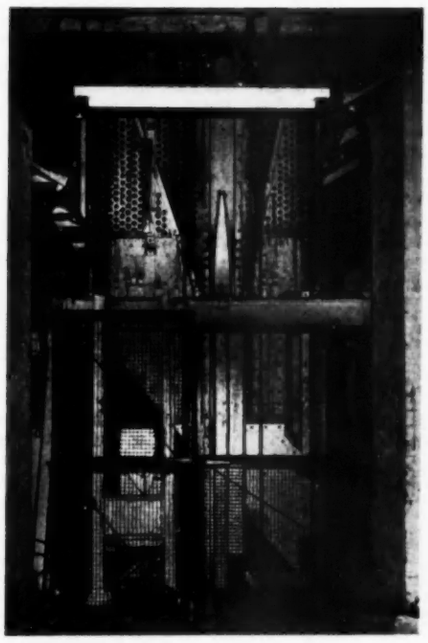
As the winder can be used for winding men, materials or salt, the winder driver is provided with a pedestal control panel with switches to select the " skip," " men " or " materials " position. If the switch is set to the man-winding position neither the skip plant nor the materials winding level can function. Similarly, if any other switch setting is selected, interlocks render the other inoperative. A further switch setting, " off," is provided to cut out all the normal operating positions. This setting is used for maintenance, shaft inspection or testing purposes, and a red warning light shows the winderman when it is in use.

Signalling and indication panels are provided at the surface for the use of the banksman, who positions himself at the appropriate panel according to the type of winding to be done. For all types of winding electrical interlocks must prove the correctness of an action before the next move in the sequence can be made. If, for example, the skip were to be signalled away on a man-winding sequence before the safety gates were closed, the winder would cut out automatically. Similarly, when skip winding is in progress, limit switches and interlocks prevent a skip from being discharged unless the skip is correctly in line, the winder brakes are on, and the hopper is ready to receive the charge.

Interlocking operates at the skip loading point underground in a similar way. The onsetter controls the filling of the skips from the measuring pockets, but can only initiate a loading operation when all the locations and conditions are correct. Illuminated panels at the winderman's, banksman's and onsetter's stations show each operator what cycle is in progress, and that it is proceeding correctly. Any failure to get the correct light signal indicates a fault, which has already stopped the cycle. This can then be traced. It may be a manual failure to carry out an essential part of the sequence, in which case it is easily rectified, or it could be a plant failure, which has to be traced and corrected. In either case, unsafe operation is prevented.



(Left)—Between the crusher and the shaft there is provision for stocking and reclaiming by power shovel. (Right)—Skip loading area, with control house on the right



A loaded skip is ready to be hoisted to the surface

MAINLY METALLURGY

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Metallurgical Progress in 1960

IRON AND STEEL

LOOKING back to note what metallurgical progress was made during 1960 it may be helpful for engineers, who naturally cannot find time to study the ever more voluminous metallurgical literature, to indicate some convenient short cuts to knowledge of what has been happening in the Iron and Steel Industry. The British Iron and Steel Federation's quarterly magazine "Steel Review" gives data concerning output capacity, relative prices, and imports and exports of steel in Britain and foreign countries.

The British Iron and Steel Research Association's Annual Report should be noted as another important source of information as to what has been happening in the industry. The research work of its five divisions and three departments may be surveyed by studying the quarto-sized booklet that has been published by B.I.S.R.A. biannually, the most recent issue being entitled "Open Report List 23," July, 1960.

B.I.S.R.A. has also been issuing to its members a continuous flow of simplified progress reports on various research projects. These are essentially brief digests and, after the first private circulation to their members has been completed, may be obtained by engineers. Some of them may prove valuable according to the specialisation of the engineer in question, for example B.I.S.R.A.'s Summary 155, "The Influence of Carbon and Nitrogen on the Magnetic Properties of Silicon Iron" will obviously interest many electrical engineers.

Pig Iron Production

The handling and treatment of iron ores was the subject of three Iron and Steel Institute papers. Two of these dealt with sintering, the value of which has become increasingly apparent. The new £2,500,000 single-strand continuous sinter plant at the Workington Iron and Steel Works was described in THE ENGINEER, December 16, 1960, pages 1021–22.

Production of Steel

Sixteen papers were published by the Iron and Steel Institute about the various aspects of steel furnace work, and the introduction of oxygen is seen to have become more firmly established in converter, open hearth, and in the newer processes of steel making. Two papers dealt with the use of vacuum techniques, the one on carbon as a deoxidising agent in the production of vacuum-melted steel, and the other on the degassing of steel by vacuum casting for the production of castings and forgings.

A very notable paper was that on the new electric melting shop of Steel Peech and Tozer, which is designed so that when completed, it will produce the equivalent of 6 per cent of the present U.K. ingot production and double the existing electric steelmaking capacity. This works is one of the four steelmaking branches of the United Steel Companies Ltd. that taken together have a capacity of not less than 14 per cent of the total U.K. production.

There was a paper on the continuous-casting plant, which came into operation at the Terni Steelworks in September 1958 to produce 5000 tons per month of 140mm by 140mm billets.

Steel castings were the subject of only one paper, that on the effect of aluminium and nitrogen on the occurrence of intergranular fracture in steel castings. However, there were papers dealing with commercial white irons, and nodular cast iron, also one about the interaction of liquid sodium with cast irons and plain carbon steels.

This section may be concluded by referring to an unexpected new entrant into the alloy steel varieties. Mr. Comtois, Canadian Minister of Mines, has announced that his department has patented what it calls an exclusive process for employing uranium as an alloy in strengthening steel. The method, is now available in the steel industry, but the Canadian patent is the property of the Crown. It is said that one pound of uranium is used per ton of steel, and that from plain carbon and low-alloy steels enhanced strength and resistance to corrosion may be achieved without a big increase in cost.

Examination and Testing of Steel

Metallography has come to provide so much of the information about the internal structure of steels that it has naturally also been outstanding in the metallurgical literature during 1960: no less than twenty of the papers to the Iron and Steel Institute could be grouped under that heading.

There have been truly amazing advances in the speed and accuracy of analysis, the classical chemical methods having been helped by the introduction of many physical methods. The symposium on the determination of gases in metals, held in London during May 1960 and attended by 300 people, gave ample evidence of this (see THE ENGINEER, August 5, 1960, pages 237-8). This was jointly arranged by the Society for Analytical Chemistry, the Iron and Steel Institute and the Institute of Metals, but in the *Journal of the Iron and Steel Institute* there were also seven papers concerning such modern techniques of determining the percentage composition of the solids and gases in steels. Two more were about developments in the use of spectroscopy.

Steels for Reactor Pressure Circuits

As a member of the British Nuclear Energy Conference, the Iron and Steel Institute held a three-day symposium from November 30 to December 2, 1960, to discuss some twenty papers on "Steels for Reactor Pressure Circuits." An excellent twenty minute, coloured film, entitled "Steel for Nuclear Power" was used to introduce the subject. This film may be recommended to almost all technical audiences and those interested in metals will note with interest that the U.K.A.E.A. has already become one of the largest users of steels. It was said to have used 14,000 tons of stainless steels, not to mention the still larger tonnages of mild steel and low-alloy steels.

The first session discussed papers on "High Temperature Properties:" high temperature mechanical properties of steels used in gas-cooled pressure vessels; metallurgical aspects of creep in carbon and low-alloy steels; and the subcritical graphitisation of steels and related alloys, the authors coming from the U.K.A.E.A., steelworks and Sheffield University respectively.

"Corrosion" was the theme of the second session in which authors from A.E.I. Ltd. introduced the relatively new subject of the oxidation of reactor steels in carbon dioxide, on which the Corrosion Group of the Society of Chemical Industry held an all-day meeting in June. (See THE ENGINEER, July 1, 1960, page 27). American authors contributed a paper on the corrosion of pressure circuit materials in boiling and pressurised water reactors.

"Fabrication Aspects" were then considered in papers on metallurgical problems associated with engineering and fabrication of gas-cooled reactor pressure vessels (Whessoe, Ltd.), fabrication of reactor vessel heat exchangers, and circuitry for the Dounreay fast reactor (John Thompson Water Tube Boilers, Ltd.).

The fourth session took us into the as yet little known field of "Irradiation Effects." Professor A. H. Cottrell of Cambridge opened the ball with a paper on theoretical aspects on irradiation damage and brittle fracture in steel pressure vessels. From the U.K.A.E.A. came a paper on the effect of neutron irradiation on the ductile-brittle transition temperature of steels and its relevance to reactor pressure vessels.

There followed two papers from the U.S. Naval Research Laboratory: studies of irradiation effects and recovery of notch ductility of pressure-vessel steels, and practical neutron dosimetry for steel irradiation studies. From the Oak Ridge National Laboratories came a paper on neutron irradiation effects in steels, and from I.N.C.O. of Canada there was a paper on the influence of some metallurgical variables on irradiation embrittlement of ferritic steel.

"Steels for Future Reactors" was the subject considered at the last sessions.

Amongst other papers the report of Italian work at Terni exceptionally interesting. There they have been making a nuclear reactor pressure vessel from forged rings and caps without longitudinal joints.

Iron and Steel Institute Meetings in 1960

In May the Annual General Meeting was held at the Royal Commonwealth Society, London, and Mr. W. F. Cartwright was inducted as the new President, taking as the title of his address "Production Control in an Integrated Iron and Steelworks." The meeting included a symposium on "Wide Strip Production" that commenced with two papers on the future requirements of the tinplate industry, and of the vehicle industry.

The fifteen papers presented at this symposium were grouped in sessions ; steelmaking for wide strip, and hot rolling of wide strip, being followed by two sessions on cold rolling and heat treatment of wide strip, and finally a session on tin coatings, galvanising, and other coatings.

The Autumn General Meeting included three separate symposia. Firstly a dozen papers were presented and discussed in four sessions under the heading of " Fluid Flow in Furnaces and Converters." Secondly half a dozen papers were presented and discussed in three sessions dealing with various aspects of " Martensite." Thirdly the Institute held a three-day symposium on " Steels for Reactor Pressure Circuits."

Iron and Steel Engineers Group

The long established Iron and Steel Engineers Group of the Iron and Steel Institute (Chairman, Mr. F. B. George) held their thirty-ninth meeting on 6th and 7th April, 1960 in London, to discuss four papers on the design and operation of heavy plate mills and their auxiliary equipment.

They also held a meeting in the Scunthorpe area from October 24 to 27, 1960 and then discussed four papers : " Developments at Appleby-Frodingham since 1954 "; " The investigation of failures in a blooming mill "; " Engineering problems in redeveloping an integrated iron and steelworks "; and " Some particular aspects of lighting in the iron and steel industry." They also made visits to the works of Appleby-Frodingham, Lysaght's, and Richard Thomas and Baldwins.

NON-FERROUS METALS

The fields of scientific interest existing among non-ferrous metallurgists are conveniently delineated by perusal of the twelve issues of the *Journal of the Institute of Metals* published during the year. We note that aluminium, copper, titanium, nickel and zinc received more attention than other metals. That brief statement is amplified by the following table, in which all the metals mentioned in the titles of papers to the Institute of Metals are tabulated in alphabetical order. The figures following the names of the metals indicate the number of times that each of these various metals was mentioned during the year.

Table I—*Metals mentioned in the titles of papers to the Institute of Metals during* 1960.

Aluminium	34	Indium	2	Rare earths	1
Antimony	2	Iron	1	Refractory metals	1
Arsenic	1	Lead	2	Silicon	2
Beryllium	1	Lithium	3	Silver	7
Bismuth	3	Magnesium	7	Tin	4
Boron	1	Manganese	7	Titanium	12
Cadmium	2	Molybdenum	3	Tungsten	4
Chromium	4	Nickel	10	Uranium	1
Copper	16	Niobium	3	Vanadium	2
				Zinc	8

These papers fell into the following four subject interest groups (1) Structure of metals and alloys ; Metallography. (2) Testing and Inspection Physical and Mechanical ; X-Rays. (3) Working, and (4) Corrosion.

The Rare Earths

It will have been noted from Table I, that there was a paper in which rare earths were mentioned. This was in the June issue and dealt with improvement of the age-hardening properties of magnesium–rare earth alloys by the addition of silver. On charts of the periodic system of the elements the rare earths of present interest may be found grouped as the so-called Lanthanide Series. But in 1960 it was advertised in the *Journal of the Institute of Metals*, that the rare earth metals can all be now produced. This was never possible in the past but research into the application of ion-exchange techniques to the separation of rare earths has made available both the basic oxides and the metals in appreciable quantities, and in several grades of purity. All of the fourteen naturally occurring rare earths, elements with atomic numbers ranging from 58 to 71, together with the related elements scandium, and yttrium, are now supplied in a variety of forms.

Non-Ferrous Metals Prices

When commenting on the prices of the non-ferrous metals at this time last year we drew up a table by placing the most used metals in groups, arranged in order of price where that was readily available.

In Table II, below, the figures given for 1959 are repeated, enclosed in brackets and figures added for the past year. They serve to show the general trends but it must be remembered that several of the metals normally have prices quoted for from two to seven grades, as supplied to industry.

British Non-Ferrous Metals Research Association

In May 1960 the Chairmanship of the B.N.F.M.R.A. was taken over by Mr. F. C. Braby, M.C., D.L. The 53,000 square feet of extra laboratory space (See illustrations in The Engineer, May 29, 1959, page 847) and increased support from the industry had by then permitted an increase in the research programme and in the staff, and recruitment is proceeding.

Among the many new researches listed, were investigations into the prevention of air pollution, and effluent treatment.

Table II—*Prices of non-ferrous metals used in* 1960, *listed in descending order of price*

Column 1.—Well-known metals, readily available and sold in such large quantities that they are priced Per Ton.

Metal	1959	1960
	£	£ s. d.
Tin	(794)	789 10 0
Nickel	(600)	600 0 0
Arsenic	(400)	400 0 0
Manganese	(245)	—
Copper	(240)	228 10 0
Antimony	(197)	207 10 0
Aluminium	(180)	186 0 0
Zinc	(91)	78 9 4½
Lead	(71)	64 0 0
Silicon	—	Nominal

Column 2.—Less common metals, sold in smaller quantities and therefore priced Per Pound

Metal	1959	1960
	£ s. d.	£ s. d.
Columbite	—	Nominal
Cerium	16 0 0	15 0 0
Calcium	2 0 0	2 0 0
Molybdenum	1 10 0	1 10 0
Tellurium	18 0	2 0 0
Bismuth	16 0	16 0
Cobalt	14 0	12 0
Cadmium	9 6	11 0
Chromium	6 11	6 11
Magnesium	2 0	2 3
Selenium	—	Nominal
Titanium (billet)	2 15 0	2 8 0

Column 3.—The traditional " Noble Metals " and others so rare as to be priced Per Ounce.

Metal	1959	1960
	£ s. d.	£ s. d.
Rhodium	41 0 0	46 0 0
Platinum	28 0 0	30 5 0
Iridium	24 0 0	24 0 0
Ruthenium	18 0 0	16 0 0
Gold	12 10 1½	12 13 6
Palladium	8 0 0	9 0 0
Indium	10 0	10 0
Silver	6 8½	6 7½
Osmium	—	Nominal
Osmiridium	—	Nominal

Column 4.—Rare earth metals newly available and sold by specialists Per Gramme, and the classic liquid metal.

Metal	1959	1960
	£ s. d.	£ s. d.
Germanium	—	—
Lanthanum	—	15 0 per gramme
Mercury	—	69 10 0 per flask

Having completed the foundry work research on gunmetals the Association issued a pamphlet entitled " Gunmetals—Choosing the Best," which will be of interest to many engineers ; so also will be its " BNF Gunmetal," an alloy giving more uniform properties in thin and thick sections and having excellent pressure tightness. A parallel research on aluminium bronze has begun.

A main feature of the B.N.F.M.R.A. work for the aluminium industry was its investigation into the casting of the high-silicon aluminium alloys that are being considered by the motor industry for cylinder blocks and other parts where their lightness, low expansion and good wear resistance are attractive. As for the wrought light alloys, there was in hand a large programme of work on the fatigue properties of medium strength structural alloys that occupied much of the equipment of the new fatigue laboratory. This should provide basic design information for the better utilisation of aluminium alloys in road and rail transport, and studies on fretting and anti-fretting were of interest to the aircraft industry.

Much of the research on corrosion in the new laboratory continued to be concerned with the use of non-ferrous metals in domestic water supplies. However engineers connected with steam generation should note that the B.N.F.M.R.A. research work on a new brass alloy for condenser tubes was extended. Laboratory tests showed that the alloy was better in polluted waters than existing condenser tube alloys ; now it has been produced on an industrial scale for service trials in ships and in power stations.

Research on electroplating, carried out in the Metal Finishing Section, led to the publication of a useful development report entitled " Better Plating on Die Casting." During the summer, in conjunction with the Zinc Development Association, the Association organised a symposium on this subject. (The Engineer, August 5, 1960).

It was reported that the B.N.F.M.R.A. had been granted a patent for a new range of compositions for lead cable sheathing alloys based on the lead–antimony–arsenic system, and field trials of a telephone cable sheathed with one of these new alloys have commenced.

Metal Development Associations

Much practical and scientific information about metals was made freely available during the past year. In particular the many users of metals, benefit from the work of the various " Development Associations." These helpful organisations have been founded and built up since 1926, in which year the present writer proposed, while in New York, the formation of the Bureau of Information on Nickel and during the following months wrote for it some of its first publications.

As yet there appears to be no development association for Beryllium, but nuclear and electrical engineers in particular will be interested in the announcement made towards the end of the year, that the Nuclear Energy Committee of the Institute of Metals is organising an International Conference on the Metallurgy of Beryllium, to be held in London during October 1961.

Rather surprisingly magnesium still appears to have no co-operative development association, but much detail regarding this metal and its alloys became available during the past year in a concise new reference book of broad scope on *Magnesium and its Alloys*. (See The Engineer December 2, 1960, page 934.) There were also papers of interest to engineers on the use of magnesium alloys for nuclear energy fuel element components. (See The Engineer, October 7, 1960, page 583.)

LETTERS AND LITERATURE

Letters to the Editor

THOUSANDS OF MILLIONS TO BE SAVED?

SIR,—I have been very interested to follow the arguments put forward by Brigadier Lloyd and his followers on this controversial subject, and as an extensive traveller by both railway and road I would be very glad if, through your columns, he could give the answer to this problem :

Every morning between sixty-five and seventy express passenger trains from starting points between 50 miles and 200 miles out of town enter the London termini between the hours of 9 a.m. and 11.30 a.m. Many of the passengers on these trains are business-men *en route* for a conference, or other activities in London. The trains are mostly heavy, conveying between ten and fourteen vehicles, well patronised, and many passengers take breakfast *en route*. In addition, the journey time is frequently used for studying documents, discussions with colleagues and so on. A total of 300 passengers per train would be a fair average.

How would Brigadier Lloyd provide for this particular traffic, and with what would he replace the corresponding swarm of expresses leaving London between 4.45 p.m. and 6.30 p.m.? On these latter the number of passengers dining *en route* is high, and in some cases like the Merseyside Express three dining cars are provided on one train. After a day in London business-men and others have come to expect a warm, comfortable and reasonably fast journey home, with an opportunity to read the evening papers, discuss the days events, dine, and probably to indulge in a nap before journey's end. Brigadier Lloyd has an answer to most things. I should be interested to know how he would deal with this one.

O. S. NOCK

20, Sion Hill,
Bath,
January 16, 1961.

SIR,—In his letter in your issue of January 6, Mr. Gordon England says that " The public have decided that what they desire, in the environment of to-day, is that they shall engage in traffic by the form of transport which gives them personal choice at all times." I take this to be a long winded way of saying that they prefer private cars to travel by rail.

I would suggest that Mr. Gordon England should visit the car parks of any of the Southern Region stations in his neighbourhood and count how many of the public, having bought cars, prefer to travel by train when a frequent electric service is available. If that is the situation to-day, how much more so will it be when the number of cars has doubled, and all the heavily loaded lines have frequent electric trains ? I suggest that there is no doubt about the motorist's preference for rail travel—his only worry is whether he can park his car at the station when he gets there.

Does Mr. Gordon England seriously suggest that the Southern Electric is an " effete transport system of railways," and, if he does so suggest, can he wonder that his is a voice crying in the wilderness ?

J. R. HARDING

Sutton Coldfield,
Warwicks,
January 17, 1961.

SIR,—In his letter of January 4 Mr. Cobon asked how long the coach journey might take between London and Glasgow or Edinburgh using converted railways. The routes northwards from Euston and King's Cross are both extensively four-tracked, and these sections should convert quite readily into dual carriageway motorways of four lane capacity, over which average speeds of 60 to 70 m.p.h. should be attainable. Upon the remaining sections of two or three-lane carriageway route an average of not less than 50 m.p.h. might reasonably be obtained, since the Railway Conversion League envisages the motor road network being reserved for use by comparatively fast moving traffic subject probably to minimum as well as maximum speed limits. The journeys to Glasgow and Edinburgh, both about 400 miles, would take, therefore, about seven hours including two stops.

The coaches used, running exclusively over the converted network, would not be restricted to the 30ft legal length limit applicable to public service vehicles running over the ordinary highway system, and they would possibly be 60ft or more in length, seating some forty to sixty passengers and might be provided with full catering facilities based upon airline practice. Since this unit of movement would have about one-fifth the seating capacity of an express train the frequency of the service might be about inversely proportional, and a basic hourly or even half-hourly interval service should be justified.

With regard to the 7.55 a.m. diesel from Luton to St. Pancras, Mr. Cobon is fortunate in having this as his regular commuting service, because it is the fastest peak-hour train from Luton, and the 59 m.p.h. schedule between Harpenden and St. Pancras is probably the fastest suburban service into a London terminus. It stands head and shoulders above the average speed of most suburban services and compares favourably with the 29 m.p.h. of the recently introduced electric services from Liverpool Street to Hertford, and 24 m.p.h. to Enfield. Upon conversion Mr. Cobon's journey would probably take about thirty-five minutes non-stop, or thirty-seven minutes with a stop at Harpenden included.

Frequency is as important a feature of a passenger service as speed, however, and whereas the service from Luton is now relatively sparse, 7.30 a.m., 7.55 a.m., and 8.11 a.m., for example, this would be much increased as a result of a reduction in the size of the unit of movement from that of an eight-car diesel train to that of a single road passenger vehicle. Upon conversion it is probable that during the peak-hour Luton would have non-stop services to St. Pancras at intervals of about every seven to ten minutes, these taking thirty-five minutes as compared with an average of nearly forty minutes for the existing eight fastest diesel trains.

P. J. SMITH

Potters Bar,
January 25, 1961.

SIR,—It seems that Mr. Cobon is under the illusion that there is some magic in the steel wheel running on the steel rail that makes it the only form of transport capable of averaging more than 60 m.p.h.

This, however, is quite wrong as can be seen from the performance of the Midland Red express buses while using the M.1 where speeds of 70 m.p.h. are quite common and no fatal accidents have taken place.

I am therefore quite confident that once the Midland line has been converted into a Motorway it will be quite easy to cover the 30½ miles from Luton to St. Pancras in thirty-two minutes or even less. The greatest advantage will be the non-stop service which will be quite practicable once buses with seating capacities for thirty to sixty passengers have replaced the bulk transportation of the railbound diesels.

The main benefits for long distance passengers travelling from London to Edinburgh and Glasgow will be the very low fares, which need be no more than halfpenny per mile so long as the Government does not impose penal taxation.

The passengers will also benefit from the quiet, smooth running buses which will provide luxurious accommodation for about sixty passengers, as is the case with the Super Golden Eagle buses which are operated by Continental Trailways between Los Angeles and San Francisco.

Even with buses of this size, which will be about 60ft long, it will be quite easy to average 65 m.p.h., so well aligned are the permanent ways. So we shall still be able to cover 400 miles in seven hours or even less.

However, for very fast travel the airliner will really come into its own, as the converted railways will provide excellent Motorway links between the city centres and the airports. This will put an end to the ridi-

culous situation where air travellers, even on journeys of several hundred miles, spend longer on the ground than in the air.

A. I. WATKINSON

Harrogate,
Yorks.
January 16, 1961.

SIR,—The rival merits of road and rail transport so interestingly debated in your columns leaves the curious reader with much food for speculation but with far too few facts and far too many doubts.

One glaring example of the gross misuse of statistics is provided in Brigadier Lloyd's latest contribution on the subject. In employing statistics to support his case that railways are more dangerous than roads he naïvely continues to omit from the railway passenger journeys, those of London Transport and "other" lines. Another weakness in his argument is including in the railway fatality figures for 1959, 101 trespassers, and "others" 33. Furthermore it is questionable whether to include the railway servant fatalities of 156 in his total, since many if not all of these would qualify as industrial accidents. His own figures used intelligently prove a very different case, that the railways are, in fact, safer and this brings the argument one stage further.

Before we can compare the costs of road and rail transport we obviously have to debit road transport with the cost of road accidents, but suppose as an alternative we estimate the cost of road transport having the same low accident rate as that of the railways. We should then have to reckon on the extra costs of giving road drivers a prolonged training and of only granting them licences provided they were not colour-blind, had a high standard of vision and could pass a stiff written and oral examination. Automatic safety devices to prevent vehicles passing signals at danger would be required. Vehicles would be inspected frequently and traffic signals erected at every road intersection. Each vehicle would be equipped with a complicated electronic guidance system so that it would follow a predetermined course at a controlled speed and bring the vehicle to rest should the driver collapse. Roads would be completely segregated from pedestrian traffic and brilliantly lighted at all times.

It seems to me that when public opinion insists on road transport being as safe as the railways it will decide that roads are too expensive. Road users and the community as a whole have to pay heavily for these safety measures whether they adopt them or not, but they probably pay more for not having them.

J. V. WALKER

Solihull.
January 29, 1961.

LAND DRAINAGE AND WATER SUPPLY

SIR,—A leading article in a recent issue of THE ENGINEER has been brought to my attention, dealing with the twin problems of Land Drainage and Water Supply. I am not aware of your degree of knowledge of the policy of this association, but, in fact, it has been advocating the formation of just such an overall water authority as you suggest since its foundation in 1946. Our recent publication, "A National Waterways Conservancy," prepared at Parliamentary request, gives an outline of the Association's proposals.

A scheme by our member Mr. J. F. Pownall, known as the Grand Contour Canal, has been in preparation since 1943. This project envisages a single level (310ft) navigation canal, some 700 miles long, capable of passing 2000 ton coastal vessels, with lifts to sea level at main ports and rivers. It is also able to act as a water grid; water being received from the headwaters of the main rivers in the west and north west, and transferred along the three arms of the canal at a rate of up to 2000 cusecs, either to the industrial and agricultural needs of the moment, or to artificially replenish natural underground reservoirs. The scheme has already been examined by a Parliamentary Committee, and has been referred to in the House on several occasions. A number of full reports on the subject have been published in the technical press.

M. J. MACFARLANE,
Hon. Joint Secretary
The Inland Waterways Association Limited,
Midlands Branch,
Dunchurch,
Warwickshire
January 20, 1961.

[From time to time reference has been made in our columns to the proposals for a grand contour canal.—Ed., THE E.]

SCREWY SCREW THREADS

SIR,—It is the practical aspect of screw threads which I find screwy. The calculation of how long a nut should be so that the core and thread strengths are about equal is not overwhelmingly difficult. Fine thread nuts will, according to theory, so I am told, have the lesser tendency to become loose of their own accord.

When I was apprenticed I spent many hours filing bolts protruding from nuts. Since then standardisation has become the fashion and storekeepers make their own lives simpler by stocking bolts only at ½in length intervals. Almost every schoolboy knows that fitters spend 90 per cent of their working time bolting and unbolting. Not infrequently, particularly in chemicals works, bolts have to be burned off because the threads clear of the nuts have corroded.

My plea then is that nuts should be made twice their present length. Stripped threads would be unknown. While the prime cost of the fastenings increased this would be compensated by lower labour costs, longer bolt and nut life, saving in lost time due to accidents caused by slipping and breaking spanners, and, I expect, a large saving in breath now used for swearing.

U. A. STRUB

Grimsby.
January 27, 1961.

EDGE CRACKING OF A STEEL BAND CONVEYOR

SIR,—The article in your "Technical Contributors' Section" for December 30, 1960, by Messrs. Parker, Furman and Chandler on the "Edge Cracking of a Steel Band Conveyor" is of great interest in showing the danger of fatigue failure which is likely to ensue when an attempt is made to run a steel band over troughing idlers, even when they are inclined at the unusually small angle of 7 deg.

For the sake of accuracy, however, it should be pointed out that the first equation on page 1101 is incorrectly given and should be:

$$2R=\frac{L^2}{4h}+h.$$

The final expression for R is, however, correct but this obviously simplifies to:

$$R=\frac{L}{2\sin\phi}.$$

This is also immediately apparent from the Fig. 8(*b*) on the same page.

Having regard to the authors' conclusions, it would be of interest to know why the National Coal Board installed the expensive and unsatisfactory rubber covered steel band conveyors instead of a normal rubber and fabric belt carried on wire ropes.

E. C. HOUGHTON
Vickers-Armstrongs (Engineers), Ltd.,
Newcastle upon Tyne,
January 11, 1961.

Book Reviews

Progress in Metallurgical Technology. Published for the Institution of Metallurgists. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 32s. 6d.

THIS small book may safely be recommended to any engineer who wishes to learn more about the materials he uses. Its 147 pages are easily readable, printed on matte paper on which there are thirty-seven clearly drawn figures, and interleaved with sixteen plates on which the photographic illustrations have been reproduced on glossy paper. Small enough to go in bag or pocket, it may be read with profit on a few train journeys.

Each year since 1947 the Institution of Metallurgists has held a refresher course for its members and from 1956 onwards the lectures given at the courses have been made generally available in volumes such as this which is the most recent of the series of refresher course publications. On page 186 of THE ENGINEER, September 4, 1959, reference was made to its immediate predecessor, which was entitled *The Structure of Metals—A Modern Conception.* The present volume will be much more readily understood by practical engineers. It contains four papers, which were the lectures given, each by a separate expert, at the thirteenth annual refresher course held in Scarborough in the autumn of 1959.

In the first sixteen pages Dr. John Taylor, principal lecturer in metallurgy at the Royal College of Science and Technology, Glasgow, deals with iron-making, steel-making, and the new iron-making processes, and concludes that, despite the revolution now taking place due to the advent of tonnage oxygen, it is improbable that the newer methods will alter

LETTERS AND LITERATURE *(continued)*

the general pattern of iron and steel production for a long time to come, at least in those countries with good reserves of coking coals.

Mr. A. V. Bradshaw, lecturer in metallurgy at the Imperial College of Science and Technology, South Kensington, London, writes in the following twenty-six pages about extraction and refining of non-ferrous metals. Autogenous grinding carried out in air-swept tumbling mills has lowered capital costs and power consumption. His references to hydrometallurgy and pyrometallurgy as now practised show that the technology of extraction metallurgy is far from moribund. Many of the processes described by this author, such as fluidisation and ion exchange, originated in the chemical industry but now result in better, or cheaper, extraction of metals from their ores.

The third paper covers twenty-one pages and its author, Dr. A. G. E. Robiette, a metallurgical consultant, considers the melting of ferrous and non-ferrous metals. Although there has been little change during the past generation in the principles of applying heat to the melting of metals, the equipment has, in many cases, changed out of all recognition. Except in the case of the cupola for general iron founding there has been a swing away from solid fuels, and the greatest advance has been in the application of electric furnaces.

The final paper is the longest and the most fully illustrated of the four. In its sixty-three pages its author, Dr. D. V. Atterton, managing director of Foundry Services Ltd., deals with the casting of three main groups of alloys, namely steels, copper alloys, and light alloys, and regrets that he could not also include mention of other important groups such as nickel alloys and zinc. It is helpful to have the practices in these three groups discussed side by side in one paper, for there are notable differences in techniques. Recently the continuous casting of steel has followed the continuous casting of copper and copper alloys into the everyday world of commercial practice. Six pages of index conclude this refreshingly practical book.

Power Stations Work Like This. By ROLT HAMMOND. Phoenix House, Ltd., 10-13, Bedford Street, London, W.C.2. Price 9s. 6d.

ELECTRICITY generation by thermal and water power stations is explained in forty-seven pages addressed to readers in the "teenage" group. These are followed by a glossary of electrical terms and—a feature often omitted in books of this price and class—an index. The author begins with Faraday's experiments in electromagnetic induction and shows how the principle is applied in the power station alternator. At this early stage the ideas of three-phase generation, r.m.s. voltage and power factor are introduced in simple terms. The generator diagrams break away from the simple loop so often illustrated, but it would have been better still if the notion of a rotating magnet had been introduced at once. Young readers are usually so wedded to the idea of the horseshoe or bar magnet that they find it hard to appreciate how and where magnetic poles are set up in a revolving cylinder.

Adequate attention is paid to the coal and oil firing of thermal stations, including layout of plant and fuel and ash handling facilities, and there is a simple description of a three-cylinder turbine with its associated plant. On similar lines the author deals with the fundamentals of nuclear fission and the heat exchanger. The chapter on hydro-electricity explains impulse and reaction turbines and proceeds to give an outline of typical schemes, including tidal power and pumped storage projects. A chapter on distribution and transmission touches on the construction of transformers and large circuit breakers, and the book concludes with a survey of future developments. All illustrations are in line: for a book of its kind this is a more satisfactory arrangement than having numbers of pictures divorced from the explanatory text in separate half-tone art sections. The reader is continually aware of the size and shape of what he is reading about.

The Uses of Electricity in the Oil Industry. A survey edited by E. A. REEVES, D.F.H. (Hons), A.M.I.E.E. Ernest Benn, Ltd., Bouverie House, Fleet Street, London, E.C.4. Price 50s.

OVER the last two years or so the *Electrical Journal* has published a series of articles covering the application of electricity to the activities of the British oil industry, including prospecting and production, refining and distribution. These articles, each covering a particular aspect of the subject, have now been brought up to date and reproduced in the book under review. To give a more complete picture of the industry new chapters have been added on control systems and on American and Continental practice.

A useful background to the whole subject is given in an introductory chapter by F. N. Beaumont of the British Petroleum Company, Ltd. He comments on the growing practice of British refineries, to take their power requirements from the national Grid, which, in the last few years, has been providing increasing security of supplies. He refers to the development of large flameproof squirrel-cage motors up to 3000 h.p., as an alternative to steam turbines, for driving large centrifugal compressors and he touches upon recent advances in electronics applied to process control.

The first two chapters of the book are concerned with the closely linked subjects of the electrical safety codes adopted by the oil industry and the importance of the certification of flameproof equipment. There follows a series of reviews of electrical practice in oil fields, both land and submarine, in tankers, refineries and depots, in the heating of oil pipelines and in lighting. A more detailed treatment of electrical plant and equipment is then given in chapters dealing with motors, control gear, flameproof switchgear, transformers, cables, overhead lines, earthing and bonding practice, cathodic protection, telecommunications and flameproof emergency alternator sets.

Coming to what is surely the most exciting aspect of the application of electricity to the oil industry, the reader finds a short chapter on control systems. It deals very concisely with the basic requirements of instrumentation, data transmission and control, with special reference to refinery processes. It starts from the elementary step of replacing a human operator by applying closed-loop local control to one or more of the parameters being measured in a particular process, and it proceeds to consider the possibilities of applying data loggers and analogue and digital computers to the fully automatic operation of refineries.

This book gives a good coverage of the subject. The matter is well put together and produced, leaving no traces of the discontinuities of style and content that might have been expected in such a comprehensive collation of articles.

Grundzüge der Strahlenschutztechnik. By THOMAS JAEGER. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.46.50.

PROTECTION from dangerous radiations is one of the fundamental problems in connection with the utilisation of nuclear energy. Over the last two decades, a large mass of knowledge has accumulated in this field, which here is assembled and set out in a manner calculated to be of use especially to the civil engineer, process engineer, and safety engineer. *Fundamentals of Radiation Protection* deals with the various nuclear interactions which are at the basis of artificial radioactivity. It then goes on to discuss instrumentation for detecting and measuring radiations, the effects which these have on living tissues, and the question of maximum permissible dosages. The reader is then introduced to the various kinds of gamma and neutron source which are of technical importance and the geometry of radiation sources. This leads to a discussion of experimental apparatus for measuring the effectiveness of reactor shields, and the mathematical calculations involved.

Biological shields require for their construction special materials, such as heavy concretes, which in their turn necessitate the use of techniques adapted to those materials. The author discusses the question of shielding in the design of radioactive laboratories, with special reference to large and small hot cells. Other topics are the design of separation plants, of technical and medical gamma installations, the shielding of particle accelerators, and the disposal of radioactive waste.

Because of the many unknown factors, safety in the nuclear field has always been a prime consideration and measures to obtain it have been very strict. The question of safety poses many problems for the engineer in connection with the design of steel and concrete shells, airlocks, pipe and cable ducts, and underground installations, ventilation, collision-proof design of ships' reactors, which are dealt with in the final chapters.

Books Received

Nuclear Propulsion. Edited by M. W. Thring. Butterworths, 4 and 5, Bell Yard, London, W.C.2. Price 50s.

Engineering Mathematics. By Robert E. Gaskell. Staples Press, 29, Great Portland Street, London, W.1. Price 55s.

Proceedings of the International Clean Air Conference. Field House, Breams Buildings, London, E.C.4. Price 30s.

Who's Who in the Gas Industry, 1961. Gas Publications, Ltd., 157, Hagden Lane, Watford, Herts. Price 7s. 6d.

Mathématiques Générales. Vol. 2. By M. Denis-Papin. Aide-Mémoire Dunod, 92, rue Bonaparte, Paris (6ème). Price NF.6.80.

Engineering Drawing for Students. By Richard Marriott. Methuen and Co., Ltd., 36, Essex Street, Strand, London, W.C.2. Price 6s.

Lobed Pressure Vessels*

By J. P. DUNCAN, M.E., M.I.Mech.E.,† and N. W. MURRAY, B.E., Ph.D.‡

An unconventional form of pressure vessel is described in which pressure is contained within a spacial structure whose members are bridged by membranes of appropriate curvature called "lobes." The developments which led to the proposal and study of this form of vessel are outlined and some associated theoretical and practical factors are considered. The design, construction, and testing of two steel laboratory models of lobed vessels are reported, and the significant conclusions reached in these studies are summarised.

THE formation in 1955 of consortia for the engineering and construction of nuclear power stations in Great Britain marked the beginning of new thinking and the reassessment of old ideas concerning the design and construction of large pressure vessels. Fundamentally, the new problems posed were the practical difficulties which, perhaps, still remain of increasing the wall thicknesses of pressure vessels proportionally to their increasing basic diametral dimensions. In the elementary membrane equation for spherical and cylindrical vessels,

$$pr = K\sigma t$$

K being a constant depending on geometry, the product of pressure and radius pr had reached a practical limit fixed by the product of practicable stress and wall thickness σt. Added to this feature, the nuclear vessels were to operate at elevated temperatures and in one of several ways were required to accept concentrated loads and moments acting on or through the membrane. Further, the reducing ratio of t/r resulted in a greater relative effect of self-weight of the membrane.

In attempting to provide for greater pressures for a given radius or greater radii for a given pressure, many old ideas for the external reinforcement of a basically thin container were revived and studied and new ideas were evolved and reported. Most of these employed the notion of transferring the circumferential forces in the wall of a vessel to a wrapping, band, or ring surrounding that wall which then became virtually a seal. In such arrangements, problems of conformity of wall and reinforcement and sometimes of buckling required consideration and these methods sometimes involved practical uncertainties.

Prior to the above developments, the statically indeterminate pressure vessel had not been favoured in engineering practice although numerous examples of such vessels, such as stayed headers, were regularly adopted in steam power plants. The necessity of accepting statically indeterminate arrangements in nuclear engineering has now resulted in a more ready acceptance of and confidence in rational analysis which alone can determine questions of design.

Lobed Vessels

At a time when statical indeterminacy was still frowned upon, the notion of a "lobed vessel" was developed in a private report[1]. This was further developed and embodied in ([2]). Since no immediate large-scale application suggested or justified itself at that time, the authors built and tested two lobed vessels for the purpose of demonstrating the feasibility of constructing such vessels in steel (as models) and of assessing their performance as containers of pressure. This paper describes these developments.

Essentially, a lobed vessel is a pressure container consisting of a spacial frame, cage, or three-dimensional self-contained structure from whose members spring three-dimensional membranes or domes. The construction is somewhat similar to that employed in early balloons where a net of cord enveloped a bag containing gas. The idea has also been used for the bottoms of elevated water towers and embodied in another manner in the construction of large low-pressure gas containers. In the form considered by the authors the spacial frame is designed to withstand the loads imposed upon it by the boundary reactions of the membranes which form, together with the frame, a pressure container. The curvature of the membrane in the direction of "hoop" stresses in the corresponding conventional vessel requires to be much greater than the average curvature of the vessel as a whole. This is achieved by arranging the membranes in a manner shown in Fig. 1, hence the term "lobed".

In such an arrangement, the membranes can be much thinner for a given size, pressure, and material than the walls of a corresponding conventional vessel stressed to the same level. The spacial frame will more than absorb the saving in membrane material since it will, in general, carry bending and shear loads as well as direct stresses. Against this, the frame may be arranged externally to the fluid space and may be made of lower grade material than the membranes. Further, it might be fabricated in practice from material of limited thicknesses by relatively non-critical welding which can be easily inspected and maintained.

The impetus in pursuing these ideas was the existence of biological shields in nuclear reactors. It was thought that the concrete and steel in such shields could be put to structural use and arranged to form the spacial frame of a lobed construction. Large quantities of steel would still be needed to contain the pressure but this steel might surround the concrete with the latter arranged as a series of inward facing concrete arches in compression. A similar arrangement of inward facing steel arches might have application in very high-pressure containers of small diameter. These ideas are sketched elsewhere[2].

The only limitations imposed on the shape of the spacial frame are those imposed by structural feasibility. Methods for analysing such frames are well developed. It seems that even essentially rectangular lobed pressure vessels might therefore be possible and might have future uses where the space available for their housing is "cubic" as on shipboard or in aircraft.

Membrane Forms.—A pure membrane is a three-dimensional surface of finite thickness which can carry uniform stresses across any normal section but cannot sustain bending or shearing stresses. A soap film is such a surface.

To design the lobes of lobed pressure vessels it is necessary to determine the geometry of the lobe so that ideally it will become stressed as a membrane. To satisfy this condition for any specified closed spacial boundary, it is necessary to find one of a family of lobes possessing the property that the sum of principal curvatures at all points on its middle surface is equal to an arbitrary constant.

Such a surface is assumed by a soap bubble blown from a curved spacial boundary. The surface tension corresponds with the membrane stress in a metal membrane. Miniature bubbles were blown and projected optically in early efforts by the authors to find sections through the zenith of membranes springing from two meridians of a sphere.

The authors are not aware of analytical methods for defining true membrane geometry although, of course, numerical methods could be applied to the known basic differential equations. They, therefore, adopted the experimental methods of allowing soap films and later plastic material to form naturally into the shapes of true membranes.

Secondary Stresses.—Real metallic membranes do not exist since extension of the surface is accompanied by changes in curvature resulting in a degree of bending and shear, which are, of course, absent in soap films. Further, the spacial frame designed to provide the membrane edge-tractions must

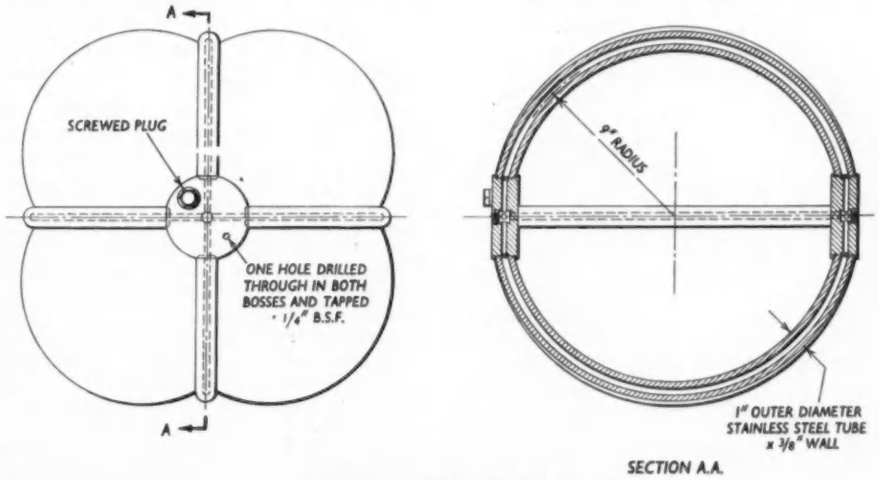

A
SCREWED PLUG
ONE HOLE DRILLED THROUGH IN BOTH BOSSES AND TAPPED 1/4" B.S.F.
A
9" RADIUS
1" OUTER DIAMETER STAINLESS STEEL TUBE x 3/8" WALL
SECTION A.A.

Fig. 1—Dimensions of vessel

* Paper discussed at the symposium on "Pressure Vessel Research Towards Better Design," Institution of Mechanical Engineers, London, January 18–19, 1961.

† Professor of Mechanical Engineering, University of Sheffield.
‡ Senior Stress Analyst, G.E.C.-Simon Carves, Erith, Kent.

distort under load and such distortion will react back on the membrane. These effects might be countered by proper geometric allowances in the design of the unloaded frame if they can be predetermined but their existence constitutes the first of the statically indeterminate effects mentioned earlier.

In vessels required to operate at elevated temperatures, the possibility exists of temperature differentials between frame and lobes which may introduce thermal stresses in the latter. This problem was treated in some detail[3] and it was shown that it is not necessarily a serious one.

The connection of lobes to a frame is a third seat of difficulty, both from the point of view of secondary stresses and of welding and fabrication. In the authors' experimental work, which was conducted on small models with limited facilities, it was a major difficulty but it is thought that it would not be an insuperable practical problem in large-scale construction.

Experiments With Model Lobular Vessels

To examine the behaviour of lobed pressure vessels it was decided that two vessels should be made. In the first case the lobes were made to have an ideal shape in which the membrane stresses predominated, and in the second case the shape of the lobes was made toroidal because in a practical vessel this shape appeared to ease the fabrication problem. A brief description of the methods of fabrication follows. Full details of the investigations are given elsewhere[4,5].

Manufacture and Testing of First Vessel.—Originally it was decided that the lobes of this vessel should have the same shape as a soap film in the hope that the bending effects could be minimised. This was because a more even distribution of membrane stresses allows the more efficient use of the material of the shell and a reduction of thickness. However, practical difficulties arose in deriving this shape from soap films because they are not of uniform thickness and measurements of their shapes are difficult.

A general view of the first vessel is shown in Fig. 1. To determine its geometry for purposes of construction, it was finally decided to use hot "Perspex" and to blow the lobes into a membrane-shape. When "Perspex" is hot it is in a plastic state and incapable of resisting shear and bending. Four lobes were required to be made from flat sheet. A steel plate was formed into an ellipse whose section at 45 deg. was a circle of 9in radius, this being the radius of the ribs to which the lobes were attached. Electric fire-bars were placed under this steel plate and the whole arrangement boxed in. A flexible cover with a shaped hole cut in it was made from thin sheet steel and this could be strapped over the elliptical steel sheet. The lobe was blown to a predetermined height which was maintained constant during the settling period by controlling the air pressure. The temperature was kept at the correct value by coating the "Perspex" with glycol. When the glycol boiled it was known that the temperature was 190 deg. Cent. and the Perspex was ready for blowing.

Because of the difficulties encountered with the handling the idea of making a "Perspex" vessel was abandoned in favour of a stainless steel vessel. The "Perspex" lobe was copied by "wheeling" which is a highly skilled hand process similar in principle to panel beating except that the forming is carried out between wheels of spherical profile.

The ribs of the vessel were made of hollow stainless steel rod to allow the effects of thermal stresses to be measured. As alluded to earlier, one of the problems associated with this type of vessel is that during temperature transients the ribs, being of thick material, would take longer to heat up and would cool at a slower rate than the shell. The hollow ribs allowed warm water to be passed through them so that this phenomenon could be studied. The whole vessel was assembled using argon-arc fillet welds. It was, of course, only possible to use external fillet welds at the lobe-to-rib junctions. Before welding the lobes to the ribs their thickness was checked at points over their surface and a maximum variation of thickness of ± 25 per cent, about a mean of 0·040in, was found. An integrated check of thickness was made by weighing each lobe. After welding the lobes to the ribs a survey of the curvature of the lobes was made. This was done by tapping a simple bar with three equispaced holes into which pointed screws fitted. Curvature of the surface was then measured by screwing back the central screw until each was in contact with the lobe. A set of gauges and a flat surface were used to measure how far the central screw had been raised and a simple calculation converted this reading to curvature. It was found that the lobes were almost toroidal in shape and this checked with earlier measurements taken on soap films. Curvature readings may be summarised as :

Mean vertical curvature	$=0{\cdot}103\text{in}^{-1}$
Maximum variation	± 12 per cent approximately
Mean circumferential curvature	$=0{\cdot}143\text{in}^{-1}$
Maximum variation	± 15 per cent approximately

Because of the very thin lobes it was anticipated that it would be difficult to obtain reliable readings of bending strains by using paired electric resistance gauges. Electric resistance gauges were, therefore, used to evaluate the membrane stresses and bending distortions were measured by using mirror pairs.

Before carrying out the pressure test of the vessel, the effects of heating the ribs were studied. Hot water was passed through the hollow ribs while the vessel was filled with cold water. Readings of water temperature at inlet and bending of the lobes at the lobe-to-rib junctions were taken.

During the hydraulic pressure tests the bending effects were again measured by mirror pairs. Strain gauges placed on the ribs gave readings which suggested that the ribs were becoming oval. This was checked by dial gauges directly and by mirror pairs. The quantity of water pumped was recorded to serve as a check on local yielding. All of the above tests were carried out in the elastic range and after results had been examined the vessel was taken up to bursting pressure. After yielding was first noted the pressure was increased in 20 lb per square inch gauge increments. A summary of test results is given below.

Manufacture and Testing of Second Vessel.—In the case of the first vessel the ribs were circular and as near as was practically possible the lobes had the shape of a pure membrane. In the second vessel the lobes were made from toroidal shapes and the ribs were made to follow the intersections of two adjacent lobes. This was done on the grounds that in practice it is easier to manufacture a toroidal shape than that of a true membrane because all component plates can be formed on one or two dies. This procedure complicates the shape of the ribs but no major manufacturing difficulties should arise.

The twelve lobes for the second vessel were supplied as 180 deg. pipe bends made from ¼in thick material, Fig. 2. It was, therefore, only necessary to design the twelve ribs to be adequately strong to carry the loads transferred from the lobes. The layout and leading dimensions of the vessel are shown in Fig. 3. In a prototype vessel

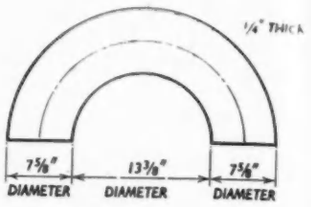


Fig. 2—Outside dimensions of pipe bends as supplied

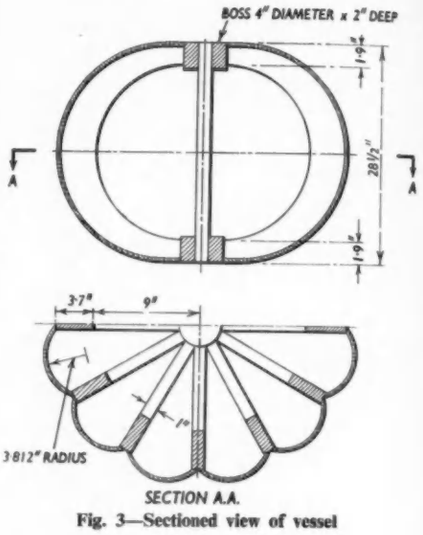


Fig. 3—Sectioned view of vessel

the ribs would be located outside the main shell but because of welding difficulties associated with the model it was necessary to place the ribs on the inside of the vessel as indicated. The ribs were designed on the simple assumption that the lobes were yielding plastically at bursting pressure. By using simple membrane theory of a torus[6], it was possible to establish certain leading dimensions of the ribs on the assumption that the ribs developed primary loads equal to their yield loads when the yield stress was reached in the lobes. A gross allowance of 0·5in was added to the depth of the ribs to take some account of bending effects.

A slight increase in volume of the vessel was achieved by moving the lobes radially outwards by an amount equal to the radius of the upper and lower bosses. This also eased the fabrication problems.

The first operation in the fabrication of this vessel was the removal of those parts of the pipe bends which were required for the lobes. A flame-cutting machine was designed to achieve this and the principle upon which it was based is illustrated in Fig. 4. The bend was set up with its diameter as abc horizontal and the scribed line in a vertical plane.

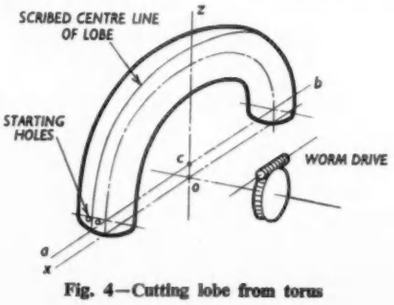


Fig. 4—Cutting lobe from torus

Point o lay directly below c at a distance equal to the radius of the boss and axis ox coincided with the axis of the vessel. By swinging the pipe bend through 15 deg. either side of the vertical plane about ox and slowly rotating the bend about axis oy with a worm drive a flame cutter could then be directed at the surface to remove the lobe. Allowance had to be made in the flame cutter mounting for adjustment in height because the radial distance from o to the surface of the pipe bend along the 15 deg. planes was not constant.

The ribs were welded to the bosses by using a special welding jig designed to avoid cumulative errors. The most difficult operation was the lobe-to-rib weld because (1) it was one-sided, (2) the rib was 1in thick while the lobe was ¼in thick, (3) no radiographing or internal inspection was possible, and (4) no strong-backs could be fitted. Lifting lugs were fitted and the vessel was stress relieved at 550 deg. Cent. for one hour and cooled in the furnace overnight.

Summary of Results

In this section the results of the two vessels are summarised. All stresses due to pressure are quoted at a gauge pressure of 100 lb per square inch gauge (i.e. stress quoted = slope of stress/pressure graph × 100).

First Vessel : Thermal tests.—The bending effects of thermal gradients between the ribs and lobes were measured on lines perpendicular to the junctions by mirror pairs. Measured stresses are given in Table I.

Table I—*Bending Stresses Due to 1 deg. Cent. Temperature Difference between Rib and Lobe*

Location	Bending stress per degree Cent., lb per square inch
Horizontal	120
2in above	144
4in above	102
6in above	93
8in above	46
10in above...	87
12in above...	48

It is interesting to compare these stresses with those from a theoretical analysis. The shape of the lobes lay somewhere between that of a two-dimensional arch and a spherical dome. Theoretical bending stresses were computed for each of these extreme cases[3].

Spherical dome ... ... 675 lb per square inch deg. Cent.
Circular arch ... ... 10 lb per square inch deg. Cent.

These figures indicate that the lobes behaved more like arches than domes. The theoretical analysis of domes and arches showed that as the amount of lobing was increased from the maximum, stresses increased rapidly at first and then decreased. Typical graphs for an arch and an "equivalent" dome are shown in Fig. 5, where it is seen that in the latter case the stresses do not die away as the angle of the dome is increased. This point is quite important because it means that since the lobes behave like arches much benefit can be derived from lobing. A more accurate analysis would need to consider the lobes as parts of tori.

First Vessel : Pressure tests.—An exact theoretical analysis of pressure loading of these vessels is not possible and it is assumed that bending stresses and strains are small compared to membrane effects. On this basis it is possible to use membrane theory as an approximate method of evaluating stresses. The accuracy is necessarily of a low order particularly because the lobes are parts of toroidal shells. Experimental membrane stresses from the delta gauges are set out in Table II and compared with theoretical stresses.

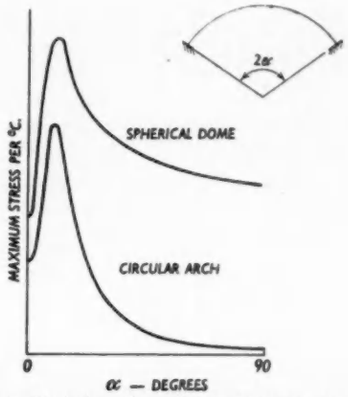


Fig. 5—Variation of maximum stress for an arch and a dome for changes in included angle α

Table II—*Membrane Stresses Due to Pressure (Second Vessel)*

Lobe	Experimental stress, lb per square inch: Hoop	Experimental stress, lb per square inch: Meridianal	Theoretical membrane-stress, lb per square inch
1	13,600	10,000	Hoop 13,420
2	18,000	11,700	
4	14,300	9,700	Meridianal 10,700
	16,700	11,600	
	13,000	7,400	

Further readings from single gauges are in agreement with these values. The maximum stress in the ribs was 7500 lb per square inch of which 500 lb per square inch was due to bending.

The tendency of the ribs to become oval was measured directly with dial gauges and showed an increase in horizontal diameter of 0·140in. This ovality was due to the geometry of the lobe. Near the horizontal centre line the angle between adjacent lobes was more acute than near the upper and lower ends of the vessel. This produced larger forces across the horizontal diameters of the ribs than across the vertical diameters.

Non-linear behaviour of the vessel was first noticed at 620 lb per square inch gauge and final bursting occurred at 740 lb per square inch gauge owing to a weld fracture. In view of the difficult nature of the welding and the fact that no stress relief had been carried out it is remarkable that the vessel was able to withstand a pressure of this order.

Second Vessel : Pressure test.—Bending stresses which occur in the lobes are quite significant in this case because of the greater thickness (½in). Mirror pairs were again used to evaluate bending stresses. The most significant result of these pressure tests was that at the central point of the lobes horizontal bending stresses of 2200 lb per square inch were measured with mirror pairs. A theoretical membrane stress of 1280 lb per square inch occurred at this point so the resultant stresses were 3480 lb per square inch on the inside of the vessel and −920 lb per square inch on the outer surface. The actual stress recorded with strain gauges on the outer surface of the lobe at this point was −1230 lb per square inch. The behaviour of the vessel which was deduced from a study of the test results showed that the horizontal diameter tended to increase because of the greater outward radial pull of the lobes in this region. This induced bending stresses in the lobes which were quite high.

Final bursting was again due to a weld failure and occurred at 1500 lb per square inch gauge.

Conclusions

One of the great difficulties which is encountered in research work on pressure vessels is that it is often more difficult to construct an accurate model of the vessel than it is to fabricate the prototype. It is usually the case that welding access to the inside of the prototype presents no difficulty whereas no access is possible in the case of a model. The vessels described in this paper are no exception. In making a model the question of tolerance must be considered. It is usually impracticable to scale down the tolerances in the same ratio as other linear dimensions. This relatively higher order of inaccuracy in models leads to local irregularities in the measured parameters, for example, strain, deflection, &c. With reservations about accuracy the advantage of a model test is its cheapness.

The two most important trends which the models brought to notice are, first, the tendency for the ribs to bend so that their horizontal diameter increased and, secondly, that the behaviour of the lobes was more like that of an arch than a dome. The first phenomenon could be overcome by making the ribs out of a braced framework which was designed to withstand the bending as well as the direct loading. If this bending is not reduced to a low order it can give rise to high stresses on the inner surface of the lobe. The second phenomenon is fortuitous because it means that localised bending in the lobes can be reduced by increasing the amount of lobing.

The economics of this form of construction has not been investigated. Because the lobes are of thinner material than, say, a sphere of the same volume and internal pressure they should be easier to fabricate and their metallurgical properties should be improved. There is a weight penalty of 50 per cent in the vessels described but this could be reduced by more judicious design.

It is difficult to imagine that any reasonably accurate theoretical analysis of a lobed vessel is possible. The accurate analysis of pressure vessels is of comparatively recent origin and it can be argued that many vessels which have given sterling service have never been properly analysed. However, codes of practice have laid down rules for the design of the conventional types of vessel.

The problem of arranging penetrations into the vessel is eased by using a lobed vessel. The penetrations can be taken through the ribs because of their high inertia to resist bending. The ribs also serve as a strong structure to reduce distortions due to external loads.

Finally it is suggested that if further work is done it seems likely that this type of vessel may be suitable as a containment vessel for an advanced gas reactor or as a pressure vessel for marine work where considerations of space may require unconventional shapes.

Acknowledgments

The first vessel was fabricated by Messrs. Bramah and Son of Sheffield, who also stress-relieved the second vessel. John Thompson Water Tube Boilers, Ltd., assisted in many ways with the project.

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[6] Timoshenko, S., 1940, "Theory of Plates and Shells" (McGraw Hill).

Automatic Marshalling Yards

A paper describing some techniques of automatic control used in gravity marshalling yards on British Railways was presented to the Institution of Railway Signal Engineers in London on January 11 by Mr. J. C. Kubale, Director and Manager, Associated Electrical Industries—GRS, Ltd. We reproduce below some extracts from the paper dealing in particular with the gathering of information on wagon rollability and the manner in which it is used to control the speeds of wagons leaving the retarders to run into the sidings.

THE yards employing automatic operation at the present time in British Railways are, in order of their completion, Thornton Yard, Scottish Region ; Temple Mills Yard, Eastern Region ; Margam Yard, Western Region. All of these yards have automatic point operation. Thornton Yard employs automatic operation of primary and secondary retarders according to preset release speeds which are manually selected by the retarder operator.

Temple Mills Yard employs automatic control of the primary retarders only and manual control of the secondary retarders.

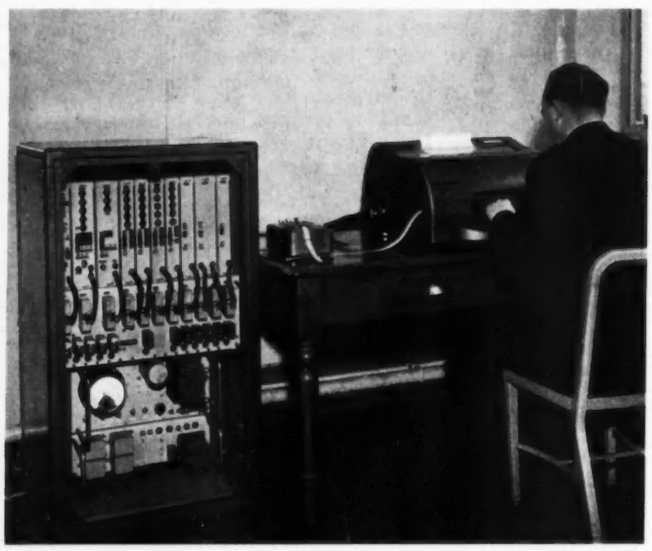


Fig. 1—Teletype machine, tape reader and converter for automatic control of points from wagon cut lists at Margam Yard

Margam Yard employs automatic control of all retarders and is thus the only one of these yards which is fully automatic.

The basic functions of a fully automatic yard are :

(1) The setting up of a cut list programme.

(2) The conversion of the programme into wagon route information for automatic point operation.

(3) A measurement of the state of occupation of sidings in the marshalling yard before humping commences and a means of changing this information for each siding as wagons travel into them.

(4) A measurement of the axle loads from which the weight category of cuts can be determined, unless this has already been given in the cut list.

(5) A measurement of wagon rollability suitable for predicting the performance of a wagon or cut after it leaves the last retarder to its destination.

(6) A means of combining the results of (2), (3), (4), and (5) above and computing therefrom the desired speeds at which cuts should be released from the retarders.

(7) A means of measuring continuously the speed of a cut as it approaches and passes through a retarder.

(8) A retarder and control system capable of responding to the results of (6) and (7) above.

(9) A means of signalling to the humping locomotive to start and stop and at what speeds it should push the wagons over the summit.

(10) Means of assuming manual control of points and retarders and thus over-riding the automatic control of these when necessary.

By one method a cut list can be delivered to the control tower operator, who then sets up the programme by depressing appropriate buttons corresponding to the destinations. At Thornton Yard a whole programme for a train of 48 cuts can be stored before humping begins. At Margam Yard the cut list when received in the control tower is typed in a teletypewriter and repeated to several offices, and at the same time a perforator prepares a paper tape. When a train has been selected for humping the tape for that train is placed in a reader which converts the teletype code into binary code suitable for feeding into the automatic point storage and setting relay network. The tape performs the programme store which with other methods require relay groups for this purpose. Fig 1 shows the tape reader and converter installed at Margam Yard.

The running distance into a siding is part of the total running distance of a wagon after the last retarder and one method of obtaining a measurement of this is to subdivide the siding by means of track circuits and to subtract from the distance so given a definite length for each wagon which travels into the siding thereafter. The siding length can be corrected whenever a wagon fails to reach its destination.

The axle load is measured by inserting in the track a specially prepared section of rail having a slotted web and contacts to indicate load categories according to the amount of deflection of the rail.

Wagon rollability should include all factors which determine the free running characteristics of a wagon or cut and is dependent upon track curvature, wagon weight, journal and flange friction. Some of these factors are difficult to measure accurately and with sufficient assurance that the results are suitable for predicting the performance of a wagon throughout its travel from hump to siding destination. Tangent rollability gives the most reliable measurement for this purpose and can be measured in various ways as the wagon travels freely over a known section of track. One method shown schematically in Fig 2 is to measure the times taken to travel over given measuring sections and therefrom to calculate the change in energy of the wagon between the measuring sections. This is then used to compare the difference of energy with the difference of elevation of the measuring sections and to modify the result according to the wagon weight to cater for rotational energy, finally storing the result as an analogue voltage for use in the computer.

Another method is to measure rollability on a known tangent track by differentiating

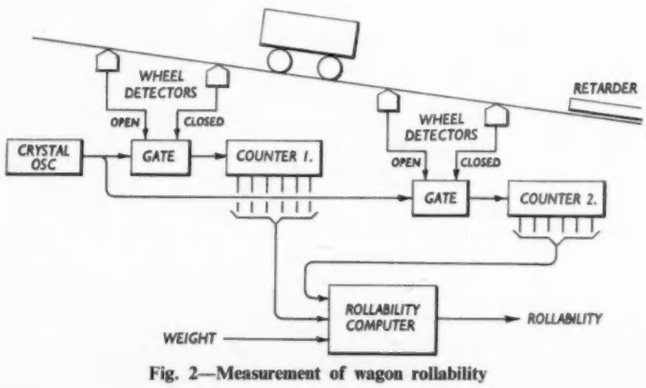


Fig. 2—Measurement of wagon rollability

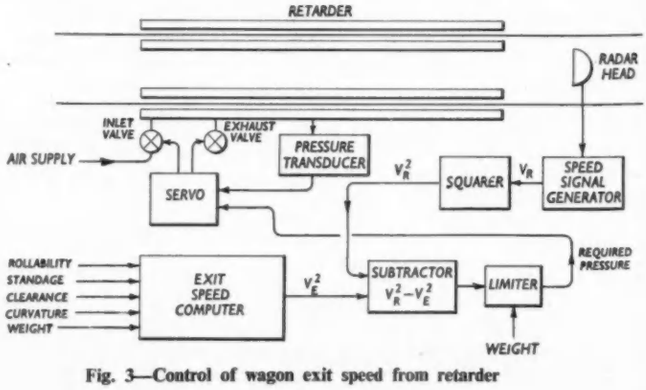


Fig. 3—Control of wagon exit speed from retarder

the speed signal of a Doppler radar observing the wagons over the measuring section and storing the result as an analogue voltage. Curvature rollability can be measured similarly over a measuring section of known curvature by either of the above methods.

The retarder release speeds are determined by analogue computers which consist of a combination of potentiometers and operational amplifiers which perform accurately and quickly the process of addition, subtraction, multiplication and division by which an equation of energy of motion of a wagon is solved. The release speed from the primary retarder is calculated to obtain approximately equal running times of single wagons to the secondary retarders and thus to reduce the possibility of wagons of different rollability overtaking each other. The release speed from the secondary retarders is calculated to allow wagons to travel to their destination and to arrive there at a safe buffing speed. This calculation must therefore include the losses of energy due to travel in the siding, and around any curves which may exist between the retarder and the tangent track, and the energy gained from any descending gradients.

The resistance offered by curves, or the curvature rollability can either be measured on a known curve for every wagon and the result used to obtain a factor assumed to be sufficiently accurate for calculating the energy losses of that wagon for all curves, or, alternatively, as the result of tests performed on the actual curves, a value of curvature resistance can be found and added to the other losses of energy for each siding.

After all these factors have been fed into the computer a result is given in the form of a highly stabilised voltage as a measure of the energy a wagon or cut should have when it is released from the final retarder. This is shown schematically in Fig 3.

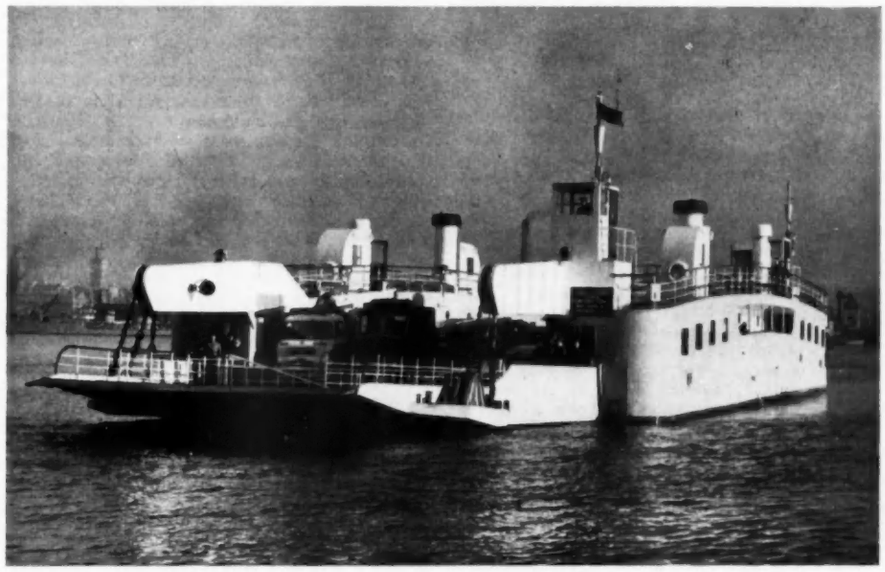
The retarder speed having been determined as the wagon is approaching a retarder, a means of comparing it with the actual wagon speed is required so that the proper retardation can be applied. The means employed is to direct a concentrated high-frequency electromagnetic beam towards the wagon and to collect the reflection of this beam and to compare the frequencies of the transmitted and reflected signals. This is the so-called Doppler radar and it provides a continuous measurement of the wagon speed while the wagon is in the path of the beam.

The transmitter and receiver form a single unit which is placed in the track and consists of a parabolic or horn-shaped antenna energised from a u.h.f source. At Thornton Yard the frequency of the radar system is approximately 3700 Mc/s which gives a Doppler signal of 11 c/s per m.p.h. wagon speed. At Margam the frequency is 10,700 Mc/s which gives a Doppler signal of approximately 32 c/s per m.p.h. wagon speed.

The retarder control system consists of a unit into which is fed the information giving wagon speed as determined by the radar unit and the desired leaving speed which has been computed. The retarder is then applied at a pressure sufficient to accomplish the desired retardation. The maximum pressure which can be applied to a wagon is dependent upon the weight category into which it is placed by the weighing treadle, as in non-weight automatic retarders excessive retarder pressure can cause the wagons to ride out of the retarder and proceed unretarded. The control system must be sensitive, and capable of reducing the pressure as the actual wagon speed approaches the leaving speed. This system is, therefore, a closed loop servo control.

The humping speed of the pushing locomotive is not automatically controlled but the speed at which the wagons pass over the hump summit is an important part of the overall operation. At Margam cab signalling has been employed. Audio frequency signals are superimposed on the track circuit of the reception siding holding the train to be humped, and when the locomotive is attached to the end of this train it picks up from the track the speed signal which the operator in the tower has selected for that track. The principal signal in the driver's cab is a visual representation of a position light signal which would be placed on the wayside and which gives a continuous signal throughout the reception lines to the hump summit. An audible signal is also given to indicate any change of signal initiated by the yard operator in the control tower.

Torpoint Diesel-Electric Chain Ferries



TWO diesel-electric chain ferries have been handed over recently to the Cornwall County Council and will replace the existing steam ferries in maintaining the service between Torpoint and Devonport which is a link in the A.38 between Exeter and Bodmin. We reproduce a photograph of one of the ferries, both of which were built at the Woolston Yard, Southampton, of John I. Thornycroft and Co., Ltd., and engined by the General Electric Company, Ltd., the consultants being Graham and Woolnough. As well as providing adequate accommodation for a large number of passengers the craft are of robust construction and capable of carrying vehicles of all classes, while the hinged prows have been so designed that fully laden long wheelbase vehicles can embark and disembark without having recourse to wheelboards.

The following are the main dimensions and particulars of the ferries :

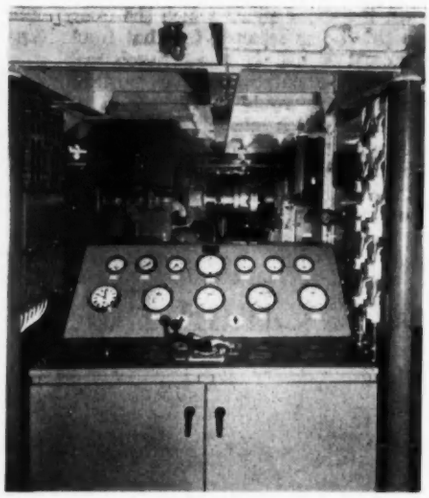
Length of hull	102ft
Length of hinged prow at each end	40ft
Length overall	182ft
Breadth of hull	54ft
Breadth of traffic deck	32ft
Depth of traffic deck at centre	9ft 6in
Depth of main deck at side	10ft
Depth of upper deck and side	18ft
Mean loaded draught	5ft 9in
Speed of chain wheels with two generators	20 r.p.m.
Speed of chain wheels with one generator	14 r.p.m.
Speed of ferry with two generators	630ft per minute
Speed of ferry with one generator	440ft per minute

Control of ferry movement is exercised from either of two cabs, one at each end of the upper deck, or from a control desk in the engine-room, both of which we illustrate. Controls are on the Ward Leonard system and are duplicated so that the propulsion motor can be operated to give ahead or astern motion from either cab controller. All decks are cambered 2ft 6in in the length and the traffic deck has space for about forty cars of average size. At each end of the wing deck-houses there are passenger cabins, and from each of these a ladderway leads up to the upper deck which is fitted with sparred seats and also buoyant seats. Forward and aft of the machinery space are ballast tanks, and ballast tanks also form the wing compartments to port and starboard except for one which is a chain locker.

Machinery

The electrical propelling installation in each ferry consists of a propulsion motor, three tandem diesel-generating sets, and auxiliary

One of the control cabs



Engine-room control desk and one of the sliding couplings

generators and a standby generator. Propulsion is by two chain wheels, one on either side of the ship, and they are driven through Wellman-Bibby couplings and a 500/20 r.p.m. double helical, forced lubrication gearbox by a 250 h.p. 440V, 500 r.p.m. separately-excited propulsion motor. Power Plant disengaging gear-tooth sliding couplings are fitted on each side of the gearbox output shaft to enable the 10½in diameter main shafts driving the chain wheels to be disconnected when required. Two Croft 45in " Multiflex " couplings are also fitted in the main shafting, one on each side of the gearbox, and cast iron self lubricating plummer blocks with gunmetal bearings carry the chain wheels and shafting. To enable spare segments to be fitted to the main chain wheels two sets of hand turning gear, of worm and wormwheel pattern, with lever ratchets are provided. By means of these each chain wheel shaft can be turned when it is disconnected from the gearbox.

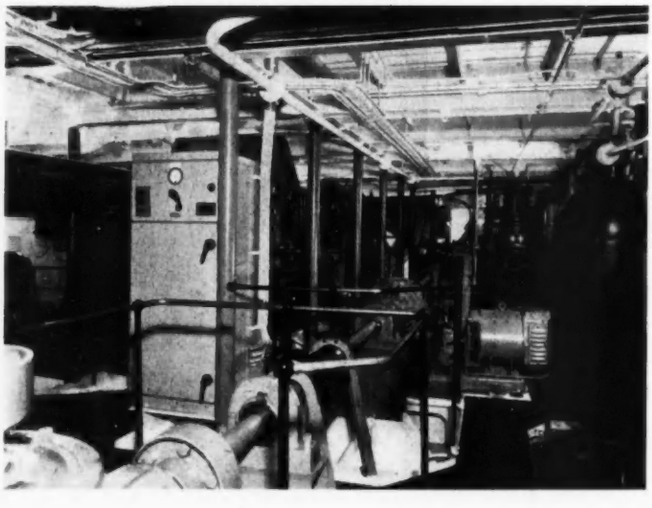
The Ward Leonard speed control system for the propulsion motor provides seven steps of speed in either direction. Maximum power for the motor is obtained from any two of the three generating sets driven by National N.M.H.8 fresh-water-cooled horizontal diesel engines, each developing 263 b.h.p. at 1200 r.p.m. Each diesel engine drives a 114kW, 220V, d.c. main generator and a 35kW, 220V, d.c. auxiliary generator in tandem. The three 114kW generators provide propulsive power and the 35kW sets supply the auxiliary machinery, lighting, heating and the excitation for the main motors. For normal service only one main generating set is used with the second set as standby and the third being available for maintenance and overhaul. Interlocks prevent more than two of the three generators being connected to the propulsion motor at any one time and take the form of solenoid-operated locks fitted in the respective generator isolators, so that when two of the isolators are closed the third is locked open.

An underspeed relay is fitted to each diesel-driven generating set so that if its speed falls below a preset value, the relay operates to remove it from the system and thus prevents motoring of the generator should another set be running. With the three-field generator system of speed control fitted it is impossible to overload the propulsion motor by mishandling the controllers. Should the controller handle be moved too quickly, the current in the armatures of the generators and the propulsion motor would tend to rise unduly. This current passes through the series fields of the generators in circuit and exerts a demagnetising influence on the excitation systems, thus preventing the overloading of the system. As a final protection against possible electrical failure an overload coil is included in the propulsion motor loop. It is set well above the normal working currents of the system and is arranged to trip the contactor supplying the main excitation circuits of the motor and generators. Earth-leakage protection is also provided for the propulsion motor loop. It consists essentially of a contactor connected between the loop and earth which is arranged to interrupt any earth fault current. At the same time visual indication of the fault warns the operator of the condition. Our illustration gives a general view of the machinery space and shows the prow motor and shafting and part of the chainwheel drive.

Auxiliaries

The three 35kW auxiliary generators and the 10kW standby generator set feed a double-busbar switchboard through a seven-position switch. The switching arrangements are such that the 35kW generators cannot be paralleled either with each other or with the standby set. Nevertheless both busbars can be fed simultaneously but independently from separate sources. The 10kW standby set is combined with a Hamworthy air compressor and driven by a Ruston and Hornsby diesel engine.

One 20 h.p. prow hoisting motor, fitted with a magnetic brake, serves both prows. It is coupled to a 900/110 r.p.m. worm reduction gearbox which incorporates emergency hand turning gear. Shafting from either side of this gearbox is then connected to 10 h.p., 110/11·2 r.p.m. worm reduction gearboxes operating the prows. Other auxiliary equipment in the machinery space includes two air receivers, one 25 tons per hour bilge pump, one 15 tons per hour general service pump and a diesel fuel oil transfer pump, all motor driven. A 16 h.p. Clarke, Chapman electrically-driven capstan, with motor and gearing arranged below deck, is installed to assist in maintenance of the main guiding chains, and is capable of exerting a direct pull from the barrel on the traffic deck of 2½ tons at 60ft per minute, the slack rope speed being 130ft per minute.



Machinery space including prow motor and shafting and chain wheel drive

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

PART 2. CHAINS AND FITTINGS

No. 4 Handbook : 1960. Price £2. The revised edition of Part 1 (Ropes and Fittings) of B.S. Handbook No. 4 was issued last year and this revised edition of Part 2, dealing with cainsh and fittings, should prove equally useful. In editing the handbook Mr. L. Linder, M.I.Mech.E., has linked the standards and statutory requirements with interesting historical and other notes.

The new book deals with the subject matter in Sections 4 and 5 of the 1946 edition. The principal material specifications which are summarised have changed since 1946 and eight of the fifteen standards reproduced in full are new since the last edition.

The editorial notes cover, among other subjects : definitions relating to chain, heat-treatment of wrought iron and mild steel, wear and servicing of chain, design of lifting gear components, design stresses, marking for quality and identification. The notes are supplemented by appendices containing tables, formulae and some material specifications. A section summarising statutory regulations relating to factories, docks, shipbuilding and building was prepared with the co-operation of the Ministry of Labour and National Service.

OBTAINING THE PROPERTIES OF STEEL AT ELEVATED TEMPERATURES PART 3 : CREEP STRENGTH

No. 3228 : Part 3 : 1960. Price 3s. With the increasing competition in international trading in pressure vessels, there is a growing demand for data concerning high temperature properties of the steels used. This publication is part of a series setting out standard procedures for obtaining such data and it relates to creep strength. Requirements are specified for the method of test, selection of samples, test conditions and the presentation of results. The object of this series of procedures, which are intended for use with B.S. 3082, " Mechanical Testing of Steel at Elevated Temperatures," is to ensure that test results are obtained by a common method so that they are acceptable to both British and foreign buyers of steel and steel equipment.

REVISED GLOSSARY OF TERMS USED IN AUTOMATIC CONTROLLING AND REGULATING SYSTEMS : SECTION TWO : PROCESS CONTROL.

No. 1523 : Section Two : 1960. Price 6s. This revised edition of Section Two of B.S. 1523 gives up-to-date definitions of the terms used in process industries for single closed-loop automatic control systems and is illustrated by diagrams. In its preparation as much as information as possible was obtained on the drafting of similar American and Continental glossaries to avoid contradiction between such drafts and the standard.

Only preferred terms are now given, as the comparative list of standard and non-standard terms included in the 1949 edition is no longer considered necessary.

OXY-ACETYLENE WELDING OF MILD STEEL

No. 693 : 1960. Price 6s. This revised standard, unlike the 1940 edition, is considered applicable to all forms of structures, other than pressure vessels and pressure pipelines for which special standards exist. It sets out the requirements for the oxy-acetylene welding of general purpose mild steel having a tensile strength not exceeding 33 tons per square inch and containing not more than 0·25 per cent carbon, 0·060 per cent sulphur and 0·060 per cent phosphorus.

Requirements are laid down for butt welds, fillet welds, cleanliness of fusion faces and workmanship, together with appropriate tests. Appendices give information about distortion control, butt weld bend tests, fillet weld fracture tests and flame conditions, and include a suggested method of preparing etched specimens.

FUSION WELDED PRESSURE VESSELS. PART 1 : CARBON AND LOW ALLOY STEELS.

No. 1500A : 1960. Price 12s. 6d. In this publication there are printed extracts from British Standard 1500, Part 1. The publication has been issued in response to requests for those parts of B.S.1500 dealing with manufacture, workmanship, inspection and testing of pressure vessels to be produced in a handy and convenient form for the use of personnel who are primarily concerned with the manufacturing aspects of pressure vessels. The contents of this publication include the whole of Sections Four and Five, and Appendix A of B.S. 1500, Part 1 : 1958, together with the relevant illustrations and other appropriate information.

SHORTER REPORTS

Conference on the Condensation of Superheated Steam

A CONFERENCE on the condensation of superheated steam will be held on Tuesday and Wednesday, March 14 and 15, 1961, at the National Engineering Laboratory, East Kilbride. It will start at 11 a.m. on March 14, for the benefit of people travelling from England by air, and the formal sessions will end at lunch-time on March 15. Opportunities will be provided for those attending the Conference to visit the Heat and other laboratories at N.E.L. during the afternoon of March 15.

For many years, engineers have argued about the effect of superheat on heat transfer from condensing steam. Some assert that superheat has a bad effect, and instal desuperheaters in process plant. But others are unable to understand how such an effect can arise. When steam is used at higher pressures for power generation, it is now common practice to heat the boiler feedwater with steam bled from the turbines. Such steam may be superheated enough to make it possible to heat the feedwater above the saturation temperature of the steam. Although feedheaters are now being designed for such "negative terminal temperature difference" operation, many designers admit to feeling their way; authoritative design data are lacking.

The National Engineering Laboratory is working on the feedheater problem, and is considering extending this work into the process field. The Conference at the Laboratory will thus serve both to make clear the existing state of knowledge in this controversial field and to ensure that the work at N.E.L. will embrace those aspects of the problem of most interest to industry. Much of the time will, it is hoped, be occupied by informal discussion, but a few papers will be presented to stimulate discussion. These include a survey of the existing state of knowledge as shown in published work, presented by N.E.L., papers by Mr. J. L. Gray of the Central Electricity Generating Board, and Dr. R. S. Silver and Dr. H. Simpson of Messrs. G. and J. Weir, and two short papers by N.E.L. describing the experimental feedheater rig which is now being assembled, and a method of using a digital computer for designing feedheaters.

It is emphasised that, although much of the material discussed will inevitably be theoretical, the ultimate objectives are strictly practical. It is hoped that the Conference will attract engineers and others concerned with problems and developments in this important subject.

For further information about the Conference, write to The Director (Heat Division), National Engineering Laboratory, East Kilbride, Glasgow.

Prestressed Concrete in Building Frames

PROFESSOR T. Y. LIN, professor of civil engineering at the University of California and head of the firm of consulting engineers, T. Y. Lin and Associates, lectured on January 23 to the Prestressed Concrete Development Group in London about recent developments in prestressed concrete in the United States. He concentrated on the application of prestressed concrete to building, where he sees the great spans and the large span/depth ratios possible with prestressed concrete as offering architects an entirely new concept in building design. "An invisible column" was his description of the upward pull exerted at the lowest point of a curved prestressed cable; using such techniques he has designed an office building with spans of 66ft by 60ft, another (twenty-two storeys high) with spans of 70ft, a factory (covering 1,000,000 square feet) with clear spans of 120ft, and a parking garage with factory-precast beams spanning 75ft between precast columns and 20ft two-way-prestressed slabs spanning between the beams. He points to savings not only in space, but in cost. The garage, which is at Beverley Hills, California, showed a saving of 25 per cent, or 200,000 dollars, over more conventional construction, he claimed. He has adopted the "lift-slab" technique widely and adapted it to prestressing—two-way-prestressed slabs only 6in thick being his "usual prescription" for the floors of buildings of this type—and by it he claimed to have been able to include two additional floors in a given height of building. Professor Lin also applies what he calls "three-dimensional prestressing" to thin shells and doubly curved shapes; a church with a hyperbolic paraboloid roof has spans of 150ft and a 100ft cantilever with a 3in thickness of concrete and an edge beam. The 90ft cantilevered shells of the grandstand at Caracas racecourse was another of his designs.

An Institute of Corrosion?

THE formation of an Institute of Corrosion and the classification of workers in the corrosion field into research workers, specialists and general practitioners, on the lines of the medical profession, were two suggestions made by Mr. C. L. Wilson at the Second Annual Dinner of the British Association of Corrosion Engineers held at the Waldorf Hotel on January 26. Mr. Wilson said that corrosion was a disease of industry and should be attacked as the medical profession attacks disease. The corrosion engineer was the G.P. of the profession. To find the answer to any problem he must have the backing of specialists and research workers. Corrosion engineers should be called in to assist designers right from the initial stages. The Institute of Corrosion was his own private idea. He thought that the three bodies concerned, the Corrosion Science Group led by Dr. T. P. Hoar, the corrosion group of the S.C.I., and British Association of Corrosion Engineers should get together and form a body to correlate work and disseminate information. At the moment there was no way of getting information without contacting someone who had an axe to grind.

Aluminium Pontoon

AN aluminium alloy small craft pontoon, built by Whittingham and Mitchell, Ltd., has been put into service recently at the marine terminal of the Milford Haven refinery of the Esso Petroleum Company, Ltd. The overall dimensions are 50ft by 22ft by 5ft 3in in depth: the pontoon was fabricated in four sections and assembled on the site before lifting into the water. Of part riveted and part welded construction, the internal framework is generally of 3in by 3in by $\frac{1}{16}$in ordinary angles, and the buoyancy is provided by twenty-four cylindrical tanks of 3ft 3in diameter by 5ft in length welded from 10 S.W.G. sheet. Each is suspended from a yoke by straps in such a way that the up thrust of the buoyance provides additional retaining force. A trunked manhole gives access to each tank, which has two transverse internal diaphragms.

Assembly of the sections is by stainless steel bolts, and the deck and sides are sheathed with hardwood bedded in bitumen, while a heavy elm fender is fitted along each side. The pontoon, which weighs about 17 tons, including 5 tons of aluminium alloy structure, floats at a light draught of 1ft 9in, and there is a reserve buoyancy of 20 tons. In its operating position the pontoon is held between two pairs of vertical steel girders by spring-loaded shock absorbing rollers which allow free vertical tidal movement and prevent any transverse movement. A 50ft aluminium alloy gangway having self-levelling steps gives access to the pontoon from the jetty.

Industrial Films

FOR many years Sovex, Ltd., Erith, Kent, has specialised in the design and construction of mechanical handling equipment to meet industrial and commercial requirements involving problems of an unusual nature. Two such installations were described in some detail in THE ENGINEER last year—"Mechanised Parcels Sorting Office" (January 1) and "Mechanised Baggage Handling Equipment for s.s. 'Oriana'" (May 6). The firm has now made a film entitled "The Mechanical Handling of Mail" which was recently shown in London. This film shows the application of Sovex equipment in post offices at Leeds, Norway and South Africa, and describes the way in which specially designed plant can speed and reduce the manpower required in sorting and transporting large quantities of mail. Following the showing of this film and a talk by Mr. S. Scott of the G.P.O. Postal Mechanisation Branch, descriptions accompanied by slides were given of a baggage handling turntable installed at London Air Terminal and a special elevator for handling coffee at the new Shell Building on South Bank. These four elevators in the Shell Building are designed to deliver trays and urns containing a total of some 13,000 cups of coffee to the forty-four floors of the building in about eight minutes.

High-nickel alloys call for a machining procedure differing in detail from that employed on metals and alloys of lower strength and ductility, and a 16-mm colour and sound film, running for thirty minutes, has been produced to show the correct technique. The film, made for, and available on loan from, Henry Wiggin and Co., Ltd., Wiggin Street, Birmingham, 16, proceeds from general considerations of tool geometry, cutting speeds, tool materials and coolants, to specific machining operations. Sawing, abrasive wheel cutting, fusion cutting, turning, boring, milling, drilling, tapping, broaching, precision grinding, thread cutting, thread rolling and spark erosion are dealt with in turn. An illustrated booklet (Publication No. 1941), complementary to the film, is also available.

Aircraft Industry Award

THE Society of British Aircraft Constructors invites applications by April 30, 1961, for the annual John de Havilland Award, which is intended to provide the opportunity of experience in any field which may help in widening a man's outlook and of developing powers of leadership.

The 1959 winner, David Hyde, undertook an expedition through three continents covering more than 28,000 miles. Starting from London in March last year, Hyde and his two companions went by sea to Tangier and drove the length of the African continent to Cape Town. From there, they shipped their Land Rover to Rio de Janeiro and made their way through South America and the United States to Vancouver in Canada, which was reached in October. During the expedition, Hyde and his colleagues made a study of airline operations and undertook market surveys in the more primitive and isolated areas of the countries they visited.

Candidates, who must be of British nationality and between the ages of 18 years and 25 years, are invited to make their own proposals for the use of the Award, the value of which is £400. These can be wide in scope though they should, if possible, have some relation to the aircraft industry or airline operation. Proposals might take such forms as travel, academic training at home or abroad, or technical, commercial or other experience at home or overseas. The proposals must not cover a period longer than a year, and part or all of the time can be spent abroad. Full details can be obtained on application from the Society's offices, 29, King Street, St. James', London, S.W.1.

SHORTER REPORTS *(Continued)*

New Radioactive Chemicals

In the few months since the United Kingdom Atomic Energy Authority's Radiochemical Centre at Amersham issued new and enlarged catalogues of its range of radioactive chemicals and sources the demand for radioactively labelled substances and other radioactive materials has intensified, and the Centre now has issued two supplements : one to the catalogue of " Radioactive Chemicals " and the other to the catalogue of " Radioactive Sources." They list, *inter alia*, eighteen new organic compounds labelled with carbon-14, ranging from insecticides to steroids —many of them in high specific activities. New compounds not previously listed are twenty-six sulphur-35 compounds, thirteen labelled with phosphorus-32 (these also include some insecticides) and twenty-seven labelled with tritium. A number of new sources are available. They include neutron sources of new kinds and improved methods of construction. Promethium secondary X-ray sources and krypton-85 beta radiation sources are also listed.

The supplements also draw attention to the availability of two ranges of material for the calibration of radioactive measuring equipment. The first range comprises absolutely standardised solutions, the certified activity and radio-isotopic purity of which are measured to a high degree of accuracy. The second range covers reference solutions which are certified, but are less accurately calibrated.

Revised charges for the irradiation of materials in the Harwell research reactors are announced. In future the charges will be based on the thermal neutron flux in which the irradiation is carried out, rather than on the particular reactor.

Uranium Agreement with South Africa

Discussions between the South African Atomic Energy Board and the Combined Development Agency held during November and December, 1960, have resulted in agreement between the Board and the Agency's constituent partners—the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority—on a number of aspects of the South African uranium production programme.

At these discussions, which were first started on an exploratory basis in February of 1960, the parties came together (in the light of experience gained under the arrangements between the Board and the Agency which have been operative since 1952) to consider, from the point of view of the Agency, a stabilisation of the price for material supplied by South African producers and a rearrangement of the quantities to be delivered. From the point of view of the Board, the parties also considered the extension of the period of operation of the existing arrangement so as to ensure the continued operation of the South African uranium industry beyond the date of expiry of the current production programme. These complex issues have been resolved and agreements have been entered into by the Board separately with the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority.

These new agreements, which are operating from January 1, 1961, take the place of the present arrangements between the Board and the Combined Development Agency which provide for the acquisition by the Agency during the six year period January 1, 1961, to December 31, 1966, of 28,350 tons of uranium oxide equivalent to an average rate of 4725 tons per year at prices varying as between individual producers and calculated on an incentive/cost formula. In terms of the new agreements the total quantity of material to be acquired by the Commission and the Authority remains unchanged, but a reduced rate of delivery will result in the deferment of 5953 tons for delivery to the Authority in the United Kingdom during the period January 1, 1967, to December 31, 1970, while the average combined rate of delivery to the Commission and the Authority during the six year period ending December 31, 1966, will be reduced from 4725 tons to 3733 tons.

Instead of the former price arrangement, agreement has been reached on a fixed price for the total tonnage to be acquired by the Authority and the Commission. This will enable each producer to receive a price related to that received by it hitherto.

These provisions of the new agreement have been made possible through the realisation by all concerned of the advantages to be gained by such rationalisation of the South African uranium industry as should prove to be feasible through the transfer of production from high to low cost producers. The new agreements will enable such transfer of production to be effected on the authority of the Minister of Mines for South Africa after recommendations by the Atomic Energy Board, and the reduction or cessation of operations by certain production units will result.

As part of the new price arrangements, the agreements now concluded provide for the transfer to South African uranium producers of ownership of Calcined Products (Pty.), Ltd., which company has been responsible for the processing of the material prior to its shipment, and undertakings have been given to maintain the quality at the same high standard as hitherto.

High-Capacity Telephone Systems

A new telephone trunk co-axial line system recently introduced by the Post Office between Oxford and Birmingham makes it possible to carry 2700 telephone circuits over two co-axial pairs in place of the previous maximum of 960. As an alternative, the new system can carry 960 telephone circuits and a high quality television transmission. Similar systems are now being installed between London and Oxford, and Bristol and Cardiff. The increased capacity is derived from the use of terminal line equipment which by up to four stages of frequency changing stacks the telephone channels into the line frequency band of 312 kc/s to 12·34 Mc/s. Repeater spacings are somewhat closer than usual, the signals being amplified every 3 miles along the route. At each amplifying point the gain is controlled automatically to compensate for the effects of changes of cable temperature. Overall additional automatic regulation is provided to compensate for the effects of temperature changes in the amplifiers and to deal with the effects of valve ageing.

Power for the intermediate stations is fed along the same conductors that carry the speech signals. Up to thirteen stations can be fed from any power feeding point. The Oxford-Birmingham route is fed with power from the terminal stations only. The voltage applied to the cable is 1000V wire to earth, 2000V between conductors. Interlocking key-controlled switches ensure the safety of staff working on the equipment and cables. A comprehensive system of alarms signals any fault condition to the staff at the terminal stations. The scheme includes identification of the intermediate station at which the fault has occurred. The Oxford-Birmingham and London-Oxford systems were designed and manufactured by Standard Telephones and Cables, Ltd., and the Bristol-Cardiff system by the Automatic Telephone and Electric Company, Ltd.

N.R.D.C.—Eleventh Annual Report

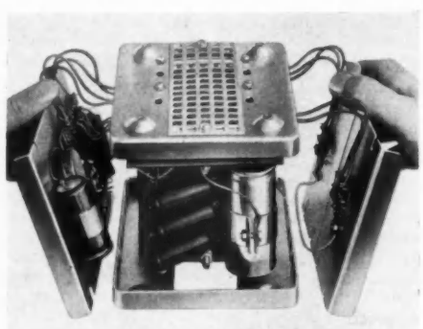
The eleventh Annual Report of the National Research Development Corporation, published last week, shows that during the period July, 1959 to June, 1960 the Corporation negotiated more licence and option agreements with United Kingdom and overseas firms than in any previous year. Eighty-one agreements were completed during the year compared with sixty-one in the previous year and at the end of June, 1960, there were 456 agreements of this kind in force. The Corporation's revenue continues to increase, and royalties and other payments received by the Corporation under licence and option agreements amounted to £259,000 compared with £182,000 the year before.

The Corporation now holds 1,066 United Kingdom and 2,042 overseas patents and patent applications for inventions which have come chiefly from publicity supported research in government establishments, research councils and the universities. Submissions of inventions from Government departments increased from 287 to 301 and those from universities from sixty to 137. Submissions from firms and individuals in the United Kingdom and overseas amounted to 511 as compared with 296 in the previous year, but the Corporation was able to accept only two of these " private " inventions as qualifying for development in the public interest. The Corporation is now providing financial assistance for thirty-five development projects.

Expenditure during the year on development amounted to £427,000, and the Corporation has entered into forward commitments for £739,000 for the development of the projects it is supporting. Some of the existing developments, like the " Hovercraft " and fuel cells, for instance, may involve further large capital commitments. The Report states that the Corporation is facing an unparalleled financial task. While industry normally pays for development work out of trading profits which it earns, the Corporation has to rely on patent royalties and specific development recovery arrangements which it makes with its licensees. These normally represent only a small part of the trading value of the developed article or process.

Transistor Power Supplies

Facilities for meeting numerous requirements in the supply of power to transistor circuits are provided on the " building brick " principle in a range of units introduced by Mullard Equipment, Ltd., Mullard House, Torrington Place, London, W.C.1. The range comprises two unstabilised transformer rectifier units with outputs up to 1A and 5A respectively at 0 to 39V, adjustable in 3V steps ; a 250mA stabiliser with a stability factor of 200:1 for mains variations between +10 per cent and −15 per cent of the nominal; and a series regulator unit. Assembly of the units into the required combination is effected by bolt fixings. The three basic items are shown in the accompanying illustration. For a 1A stabilised supply, for example, the requirement would be one 1A unstabilised unit, one 250mA stabiliser, and two series regulator units. The maximum voltage from combinations incorporating the stabiliser or series regulator units is 30V. Coarse control of the output voltage is governed by adjustable taps on the mains transformer of the unstabilised



Power supply unit (centre) with stabiliser (left) and series regulator sub-assemblies (right)

units, and fine control by a preset potentiometer in the stabiliser.

In addition to its main output, each unstabilised unit has two subsidiary outputs. Those of the 1A unit provide 200mA at 6V, 12V, and 24V and 20mA at 36V ; those of the 5A unit provide 1A at 6V, 12V, and 24V and 100mA at 36mA.

Fully Articulated Dumper

ARRANGEMENTS have, we are advised, been completed for John Blackwood Hodge and Co., Ltd., to distribute the " Leedsall " Dumper manufactured by Robert Hudson, Ltd., of Leeds, which is of 5 cubic yards struck capacity (7 cubic yards heaped), is mounted to a heavy duty Fordson " Power Major " tractor, and has been designed to withstand the roughest usage under all conditions.

The body is constructed throughout with ¼in steel plate reinforced with ⅜in " press brake " section stiffeners ; the bottom is further strengthened by rolled steel angles welded to the inside. The trailer chassis, of "A" frame configuration, is built from 9in by 3in rolled steel channels, in common with the rear axle beam. This rigid chassis is connected to the tractor by a specially designed Hudson articulated coupling.

This 5 cubic yard dumper is powered by a basically standard Fordson tractor ; notice the large air reservoir for the trailer brakes, and the access door for the cab in front of the driving wheels

Tipping is by single acting hydraulic rams operating at 2000 lb per square inch. The air compressor, which also provides power for the brakes, complete with tank, is fitted to the tractor and a quick release is provided on the air feed line.

The loaded weight of the tractor and dumper trailer is 31,870 lb. The overall length of the combination is 22ft 10in, width is 7ft 6in and the turning circle is 27ft.

In addition to the " Leedsall " dumper trailer Blackwood Hodge distribute the products of a number of United States manufacturers.

[Reply Card No. E1771]

Broadcast and Communications Transmitters

SINCE introducing an 0·5kW version of its " Q " range of m.f. and h.f. transmitters, the Engineering Division of British Sarozal, Ltd., 22, Berners Street, London, W.1, has supplied a number of units to Portuguese territories in Africa. Among these is a medium-wave broadcast equipment for the Radio Clube do Huambo, at Nova Lisboa, Angola. This territory is at present served mainly by short-wave networks, and also receives a service from Praia, Cape Verde Islands, through a station equipped with one of the larger transmitters in the British Sarozal range—a 5kW unit operating on 3960 kc/s.

The new 0·5kW stations comprise two 0·25kW transmitters feeding the aerial system through a combining unit. In the event of either transmitter failing, the station continues to operate without a break at reduced power, since a patented circuit arrangement in the combining unit eliminates feedback from the operative transmitter into the one which is temporarily out of service, so that all available power reaches the aerial. The same facility allows for maintenance without shutting the station down, and is an even greater asset for communications services, particularly those concerned with civil aviation. The transmitters are therefore also supplied for commercial telephony and c.w. working. In operation, the combining unit is set up from a calibration chart and performs its isolating function by reason of its inherent characteristics, no relays or switching being involved.

Each transmitter unit consists basically of crystal oscillator, intermediate amplifier and power amplifier stages. When two are operating together as an 0·5kW station, the crystal oscillator in one unit is replaced by a two-stage phasing amplifier, to which is fed a small input from the oscillator stage in the other transmitter. The phasing amplifier output provides the drive for the transmitter in which it is installed, in the correct phase relationship for the combining unit.

The crystal oscillator and phasing amplifier units plug into the transmitter front panels, and the oscillators have independent and separately-fused stabilised power supplies. If it is desired to radiate two programmes on different frequencies, a station can be converted in a few minutes by plugging a crystal unit into the second transmitter in place of the phasing amplifier and connecting a separate modulation source. External speech amplifiers are used for modulating the transmitters. Two designs are available, one for broadcast work and the other for commercial radiotelephony. The latter has a reduced audio-frequency range to limit the bandwidth of the radiated signal. Modulation is applied to screens and anodes of the power amplifier stage, and modulation depth is shown by a neon indicator, which also serves as a keying indicator on w.t. The transmitters are already suitable for c.w. transmission at keying speeds up to 200 w.p.m., and a keyed modulator for m.c.w. working is being developed. V.F.O. control can replace the crystal unit in the communications versions if desired. Conversion equipments are available for existing British Sarozal 0·25kW transmitters to enable them to work in pairs through a combining unit as described above.

Frequency ranges of the broadcast transmitters are 535 to 1605 kc/s and 2 to 20 Mc/s. Communications transmitters are supplied normally for 2 to 20 Mc/s, or 1·5 to 20 Mc/s on special order. Low-frequency telegraphy transmitters, 400 to 600 kc/s, are also available. Combining units for all bands are continuously tunable. Power output of the stations on telegraphy, both h.f. and l.f., is 0·7kW.

[Reply Card No. E1772]

Fire Protection at Sea

A SYMPOSIUM on " Fire Protection at Sea," sponsored by Turners Asbestos Cement Company, Ltd., was held on Thursday, January 26, and illustrated talks were given by Mr. F. Rushbrook, Mr. L. A. Ashton, B.Sc., and Mr. J. Melville. The illustrations shown by Mr. Rushbrook included examples of fires in harbours, docks, warehouses and on ships at sea, and he briefly described cause and effect and went on to point out the mistakes made in tackling fires. These, he said, stemmed from lack of knowledge of the inherent dangers of using the wrong fire fighting technique. He gave instances where the use of steam smothering was not only not suitable but actually added to the danger, and advised the employment of a spray nozzle in preference to a portable foam extinguisher for dealing with small oil fires in engine rooms. The need to ventilate the space where there was a fire was emphasised, and also the value of installing inert-gas producers. For dealing with fires in the harbour area, the formulating of a master plan and the creation of a central authority was advocated.

Mr. Ashton described various experiments carried out by the staff of the Joint Fire Research Organisation at Boreham Wood, with particular reference to insulated steel and aluminium alloy bulkheads and decks. The results of some of the work were shown graphically with the temperature rise plotted on a time base. Mr. Melville, the technical manager of Vickers-Armstrongs (Shipbuilders), Ltd., described the fire protection precautions which the company had adopted on the liner " Oriana." These consisted of three phases : fire prevention, detection, and extinguishing. A general outline of the ship indicated the position of the main fire resisting divisions and fire screen bulkheads, and particulars were given of the insulation treatment adopted for steel and aluminium alloy structures. For fire detection the value of a fire patrol was emphasised, both during building and at sea, as was the use of smoke detecting and audible alarm systems. For extinguishing fires, the cargo spaces in the liner were covered by the inert gas system while in the passenger and crew and other spaces a sprinkler system was installed consisting of forty-eight separate installations and 5000 sprinkler heads. "Mulsisprayers" fitted to a fixed installation of pipework afforded the means for protecting the tank top and for dealing with oil risks from equipment above the floor plates in the machinery spaces, while in addition hydrant valves and diffuser nozzle equipment was available to attack small fires. The value of the fire precautions taken during the building of the ship, fitting out, and on sea trials was illustrated by the number of calls and incidents which occurred during this period, the total being 115. An approximate nett cost of fire protection for the ship, excluding necessary structure, was given as £422,000 which included : £100,000 for insurance ; £120,000 for the sprinkler system ; £96,000 for insulating materials and fire resisting doors ; and £48,000 for " Mulsispray," fire system piping &c.

[Reply Card No. E1773]

Institute of Refrigeration Dinner

THE sixty-first anniversary dinner of The Institute of Refrigeration was held on Wednesday, January 25, at Grosvenor House Park Lane, London, and was attended by over 700 members and their guests with the President, Engineer-Commander W. R. Sinclair, R.A.N. (Retired), in the chair. In proposing the toast of " The Institute of Refrigeration ", Dr. The Right Honourable Charles Hill, M.P., commented upon the changes wrought by the rapid advance of science and heavily underlined the need for exports. An island with a population of over 50,000,000 and lacking raw materials had, he stressed, no choice in the matter, and those who pointed to the success of the chemical industry needed to be reminded of the large import bill for its raw material, petroleum. He mentioned that we had the ingenuity of British science for export, and noted the part played by the National College developments, and also the vital role of all such professional bodies. Commander Sinclair responded, and drew attention to the expanding membership and to the work of the committees, and in reference to the last meeting, held in Paris, commented that knowledge had often defeated national prejudice and so had opened the way to international agreement. The President also reminded members of the meetings of number 2, 3 and 8 commissions of the International Institute of Refrigeration which are to be held in Cambridge on September 20, 21 and 22 and are being organised by Mr. K. C. Hales. Commander Sinclair also announced that the Council had invited Mr. C. M. Brain to be the President for 1961.

SHORTER REPORTS *(Continued)*

Cables and Repeaters for "Compac"

THE form of submarine telephone cable to be used in the trans-Pacific link of the Commonwealth system (see our January 27 issue, page 105) was proposed by the United Kingdom Post Office to replace conventional armoured cable in deep waters, and developed in collaboration with the industry. Armouring against possible danger by ships' anchors or fishing trawls is not required at the depths at which all but some 270

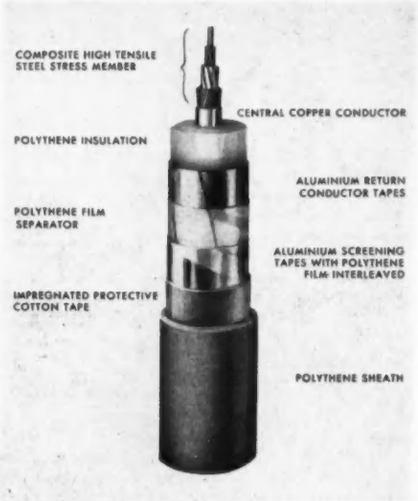


Fig. 1—Stepped specimen of unarmoured ("lightweight") coaxial submarine telephone cable

miles of the 8000-mile route will be laid. The unarmoured, or lightweight, cable dispenses with the usual outer helical lapping of steel wires, and the mechanical strength required for laying is provided by a torsionally balanced strength member of high tensile steel in the centre of the cable. This is seen in Fig. 1, showing a section

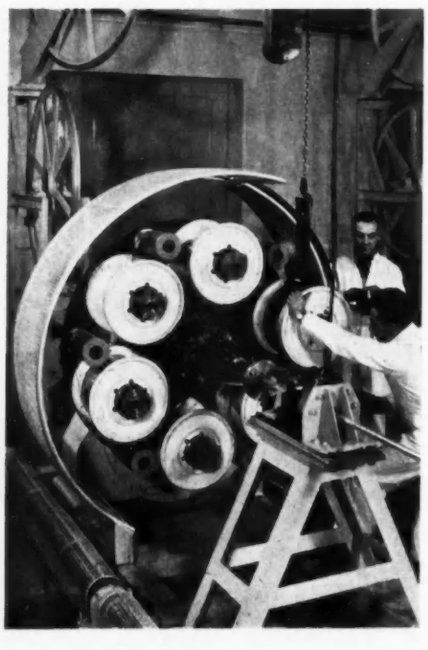


Fig. 2—Forming the coaxial outer conductor of six aluminium tapes over the extruded core

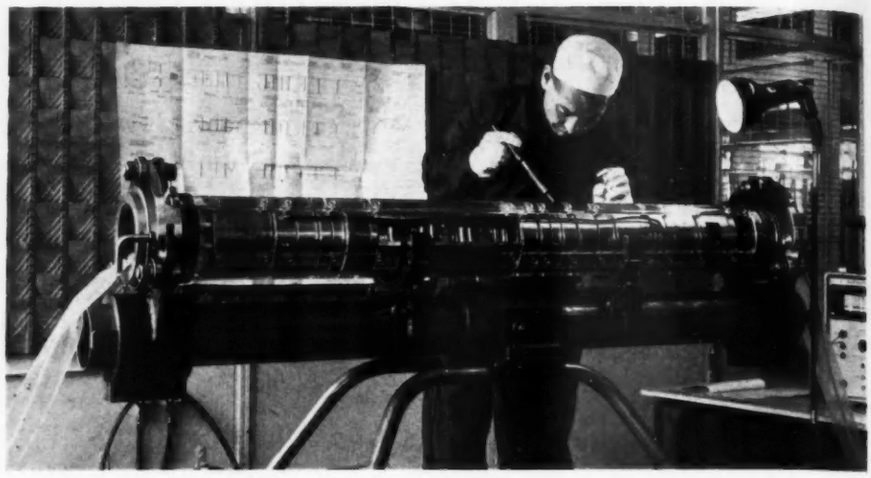


Fig. 3—Wiring a submerged repeater amplifier unit

of cable of this kind manufactured by Submarine Cables, Ltd., which is to produce 5875 miles of cable for the Commonwealth trans-Pacific (COMPAC) project.

The central member is surrounded by a copper tube forming the central conductor, which is then insulated with polythene to a diameter of approximately 1in. Aluminium tapes, forming the outer conductor, are laid over the polythene together with a polythene binder tape and a single aluminium screening tape. The whole is given a lapping of anti-corrosion tape followed by an outer sheathing of polythene to an overall diameter of about 1¼in.

It is stated that an armoured cable of the same overall diameter (but having a considerably lower electrical performance) would, in air, weigh half as much again, and in water no less than three times as much as the unarmoured lightweight cable. Furthermore the unarmoured cable does not twist or kink when being handled, thus easing the problems of laying, particularly in deep water.

The inner copper conductor and the outer aluminium-tape conductor together comprise a communication cable of coaxial form to carry the high-frequency currents (ranging from 60 to 608kc/s) corresponding to eighty simultaneous bothway conversations using 3kc/s channel equipment, or sixty with a 4kc/s spacing. The inner conductor also carries a direct current which passes along the cable and through each repeater in succession, returning via the sea, in order to energise the valves in the repeaters. The voltage required at each end of the cable to maintain this current will, for example, be about 5000V for the longest section of the COMPAC scheme.

A further 2800 nautical miles of similar cable for the Pacific route are being supplied by Standard Telephones and Cables, Ltd.

Submerged repeaters will be inserted in the cable at intervals of about 26 miles. A Standard Telephones and Cables two-way submerged repeater in course of wiring is seen in Fig. 3. The amplifier unit consists of two separate amplifiers coupled in such a way that in the event of failure of one, the other can carry on indefinitely with negligible loss of overall performance. This company is to supply 242 of the repeaters and all the equalisers (thirty-eight) required for COMPAC. A further ninty-three repeaters and all the housings are being supplied by Submarine Cables, Ltd. In the construction of repeaters, over 300 electrical components are assembled in brass or copper containers to form in all about eight units which are mounted in a framework of "Perspex" bars and enclosed in a hermetically sealed thin brass tube. The latter is then inserted in a thick steel-tube housing capable of withstanding sea-bottom pressures up to 5 or 6 tons per square inch.

Some approximate data for the COMPAC cable route (scheduled for completion in 1964) are tabulated below :

Portion of route	Cable length (nautical miles)	Number of submerged repeaters	Maximum depth of water (fathoms)
Sydney–Auckland	1,242	49	2,600
Auckland–Fiji	1,214	49	2,500
Fiji–Fanning Island ...	2,002	76	3,000
Fanning Island–Vancouver	3,544	140	3,400
Totals	8,002	314	

The two ends of lightweight cable which have to enter a repeater are armoured for a few fathoms each side of the repeater so that the tension in the central strand may be transferred through the various layers of tapes and polythene to the armour wires. These armour wires (or the armour wires of the conventional armoured cable used in shallow water) are anchored in clamps attached to each end of the housing. Machined bulkheads are brazed into each end of the housing proper ; thus the brass inner tube does not have to withstand sea pressure.

The outer-conductor tapes are terminated on the bulkheads whilst the inner conductors pass through a gland which forms an integral part of each bulkhead. The completed repeater is about 10ft long, 10½in in diameter and weighs half a ton. Extreme care is taken throughout all stages of production of a repeater in order that it may have a service life, undisturbed on the ocean bed, of at least twenty years.

[Reply Card No. E1781]

High Temperature Conveyor Belt

A "TERYLENE"-REINFORCED, heat resistant conveyor belting suitable for temperatures up to 400 deg. Fah. has been introduced by the Goodyear Tyre and Rubber Company (Great Britain), Ltd., of Wolverhampton. The belt is made in widths and plies appropriate to the required conditions of service, and with two types of carcass reinforcement. One of these reinforcements has a rating of 90 lb per ply per inch with vulcanised joints and 50 lb with mechanical fasteners. The other reinforcement rating is 112 lb per ply per inch for vulcanised and 54 lb for mechanical fasteners.

These "Thermo-Flo" belts can be made into endless lengths by vulcanised joints before delivery from the maker's works, or on site by the firm's mobile field splicing service.

[Reply Card No. E1782]

Torque-Controlled Pneumatic Screwdriver

A TORQUE-CONTROLLED screwdriver and nutrunner introduced by the Consolidated Pneumatic Tool Co. Ltd., of 232, Dawes Road, London, S.W.6., is designed to reduce the risk of stripped threads and distorted workpieces during tightening of screws and nuts. This tool has a normal capacity for driving screws from No. 4 to No. 8 and incorporates a "Magnamatic" clutch assembly which gives a range of torque adjustment from 5 lb to 20 lb per inch for lightly driven work, or a maximum torque of 40 lb per inch when running nuts or screws with instantaneous stopping.

The clutch assembly consists of two adjoining, co-axial cylindrical members having teeth of a special form machined in their opposing annular circumferences. The upper cylinder is rotated by the air motor of the tool and the lower cylinder is connected to the screw driving spindle. Through its supporting stub a cylindrical permanent magnet is screwed into the upper cylinder, and the magnet projects into the lower cylinder in which it is a sliding fit. The magnet is normally in contact with a plate of the opposite

Torque-controlled screwdriver or nutrunner

pole fixed at the end of the lower cylinder bore to hold this member up with its teeth in mesh with those of the upper number. The torque required to separate the driving and driven members of the clutch depends upon the depth of contact of the inclined teeth and is varied by adjustment of the meshing depth of the teeth. When it is required to reduce the torque applied through the drive the magnet is screwed down from the upper cylinder to push the lower member outwards and decrease the depth of tooth engagement. To increase the torque the magnet is screwed inwards.

When the tool is in operation and the required torque has been applied to a screw the teeth of the driven member slide clear of those of the driver against the pull of the magnet, which is constant. At the stage where the teeth disengage a latch is tripped to hold the parts out of engagement until the tool is removed from the work. When pressure on the work is released this latch is automatically disengaged to restore the drive ready for the next operation. A second clutch is interposed between the main clutch and the driver spindle and a light spring in this clutch keeps it open so that the final drive to the tool spindle is not engaged until an axial pressure is applied by contact with the screw or nut.

[Reply Card No. E1791]

Water-cooled R.F. Power Valves

A METHOD of anode cooling which makes the valve cheaper to install and easier to maintain is embodied in three new Ediswan water-cooled r.f. power valves introduced by the Industrial Valves and Cathode Ray Tubes Department of A.E.I. Radio and Electronic Components Division, 155, Charing Cross Road, London, W.C.2.

Industrial radio-frequency power valve with water-tube anode cooling

As seen in the illustration, instead of the conventional water jacket, a spiral copper water tube is attached directly to the connector portion of the anode outside the valve envelope. Water leakage risk is reduced by absence of seals, the spiral jacket portion and connections being integral with one another. The valves are type 15P12 with maximum anode dissipation of 0·6kW and maximum r.f. power output of 2·5kW; and types 16P12 and 16P13 both with maximum anode dissipation of 3kW and maximum r.f. power output of 7·5kW. An Ediswan patented over-dissipation protection device is incorporated. Suffixes 12 and 13 denote the type of water coupling provided, e.g. the 16P12 is connected by flexible tubing, the 16P13 by unions. The 15P12 has a grid constructed of a new non-emitting material which permits much higher grid dissipation. Maximum operating frequencies at full power (limited by the water connection) are 60 Mc/s for the 15P12 and 40 Mc/s for the 16P12 and 16P13.

[Reply Card No. E1792]

Magnetic Plastic Strip

AN addition to the range of permanent magnets made by James Neill and Co. (Sheffield), Ltd., Napier Street, Sheffield, 11, is a plastic strip which is impregnated with "Feroba" magnetic powder, and can be cut to the required length with an ordinary knife. The strip is $\frac{1}{8}$in wide and $^{11}/_{64}$in thick, with a longitudinal groove of $^{1}/_{64}$in radius in one of the $\frac{1}{8}$in faces, and the magnetic poles are on opposite sides of the groove. The other $\frac{1}{8}$in face blends into the sides with small radii. In addition to being cut the strip can be drilled by normal means, and bent to a radius of $1\frac{1}{2}$in at room temperature. When warmed it will bend to a smaller radius and then, on cooling, will retain the shape it has been given.

It is claimed that the magnetism is permanent, and can only be destroyed by burning the strip. Heating the strip for bending is not critical; overheating would destroy the plastic before there was any permanent effect on the magnetic properties. The strength of the magnetic grip is proportional to the length of strip in use, but the existence of a gap between the part held and the magnetic strip, as caused by a film of paint, for example, naturally causes loss of strength. The force available can be determined from the following approximate values:

Gap (in)...	0	0·005	0·010	0·015
Pull per inch length (oz.)	3	2·5	2	1·5

For mounting the strip the manufacturers recommended "Evo-stik" impact household adhesive or the "Araldite" household two-tube pack; alternatively, as already stated, it can be drilled for nailing or screwing in position. Apart from its obvious uses for such purposes as retaining steel doors or lids in the closed position, or as a retainer or marker on magnetic notice boards and wall charts, the strip has already found numerous uses in engineering workshops. Among these may be mentioned its application as work-holding strips on the surface of a belt conveyor carrying components from a power press, and as a swarf collector in a coolant clarifier.

[Reply Card No. E1793]

Coast Protection: A Rational Approach

THE design of coast protection works remains one branch of engineering which is largely rule-of-thumb, and has been little influenced by the spate of contemporary physical discovery. A recent report of the Hydraulics Research Station* is of interest in providing at least the basis of a more rational approach to such design. It is pointed out in this report that "the general field of coast erosion and protection presents the engineer with some of the most complicated and intractable problems in hydraulics and sediment transport" and that "many more years of effort will be required before coastal engineering can be placed on a sound scientific basis." Nevertheless as good a guide as possible is needed to immediate problems, and the Station has therefore summarised what it considers to be the best answers at present available to nine questions which are thought to cover the points on which information is most frequently required.

The nine questions are as follows: what are the effects on various beach materials of waves and currents?; can beach changes be forecast?; what investigations should the designer make into sources and destinations of beach material—what action should he take in the light of the information obtained?; what action should a designer take when apparently no material is arriving on a beach and the level of the beach continues to fall over several years?; how should the designer decide whether or not groynes are desirable in a particular case—how should he decide on the spacing length, height, profile, orientation?; what causes lee-side scour—how should the problem be dealt with by the designer of sea defences?; what are the relative merits of permeable and impermeable groynes?; how should the designer determine the profile of a wall, especially to avoid toe scour?; how can the designer determine the greatest depth at which shingle is moved in a particular case?

It is stressed that, with further research, fuller and more precise answers should be possible.

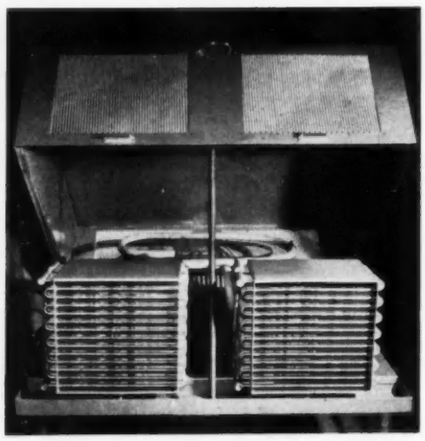
* Hydraulics Research Paper No. 3, "Coast Erosion and Protection. Nine Questions and Answers," by R. C. H. Russell, A.M.I.C.E. H.M. Stationery Office. Price 1s. 3d.

SHORTER REPORTS *(Continued)*

Automatic Dehumidifiers

MOISTURE has many new targets for its detrimental effects to-day in the increasing variety of data processing and other electronic equipment used in industry. Special problems of this kind direct attention to the more general ones of protecting products from damp and of drying out new buildings. Hitherto the use of chemicals or ducting in dehumidifying plant has been a deterrent to its widespread adoption. Without these handicaps, portable equipment needing no installation becomes practicable and may be an economic proposition for a much wider range of users. In order to meet this demand a range of " Hygro-Robot " dehumidifiers operating on the refrigeration principle is being introduced and developed by British Sarozal, Ltd., 22, Berners Street, London, W.1. No chemical agents are used in these appliances.

In these units air is drawn in at one end by a silent-running fan and passes over evaporator tubes cooled by a compressor refrigerating system. The compressor is a self-contained



Large-capacity mobile dehumidifier for automatic control, showing refrigerating units on drip tray

sealed unit running in oil. The condenser of the refrigerating system is located next to the evaporator, so that after the air has been cooled to below dew point and has lost its moisture, it is warmed by passing over the condenser tubes before being discharged. The system is flexible, and provision can be made for extra warming of the air or for further cooling if required. The dehumidifiers operate under automatic control and require no supervision after the conditions it is desired to maintain have been preset. An application of the units which is likely to overcome a long-standing difficulty is dehumidifying in the holds of ships, where changes in ambient temperature during a long passage can lead to heavy condensation. A further application of growing importance is for specialised conditions where products are stored in packaged form in locked stores, often in unheated areas, but must suffer no deterioration. The dehumidifiers might also lend themselves to grain drying without detriment to germination.

Another use of the " Hygro-Robots " is for quick and safe drying out of new buildings, without dependence on atmospheric conditions, as an alternative to forced heating methods which cause moisture to be sealed in the structure and later damage the surface. Units of a lower-capacity range, such as model 5055 (capacity 52,000 cubic feet, 40 to 100 per cent R.H.) are available for drying out small and medium size buildings, whereas the latest A492 (30 to 100 per cent R.H.) units are more suitable for large office blocks, laboratories, hospitals, nuclear stations, and so on where it is essential to ensure that dampness in the structure has been completely eliminated.

We illustrate a model from the A492 series (105,000 cubic feet capacity). The three versions in this range are the 492A for ambients from 53 deg. to 95 deg. Fah., the A492B for ambients from 41 deg. (37 deg. in a model for ships' holds) to 95 deg. Fah. (or up to 104 deg. Fah. in special circumstances) and the A492-S, a special model originally developed for the chocolate and coated paper industries. Dimensions of the unit shown are 3ft 3in wide by 3ft high (including height of castor-mounted stand) by 3ft 3in deep. A $\frac{3}{4}$in outlet pipe is provided for water discharge and is adjustable for direction. Discharge rate (depending on temperature and humidity) is in the region of 17 gallons per twenty-four hours. Air is circulated at the rate of 63,000 cubic feet per hour. This model is made for the time being for three-phase supplies only and has a consumption of only 1·1kW (the smaller dehumidifiers of the 5055 series, however, are suitable for operation from any single-phase mains point).

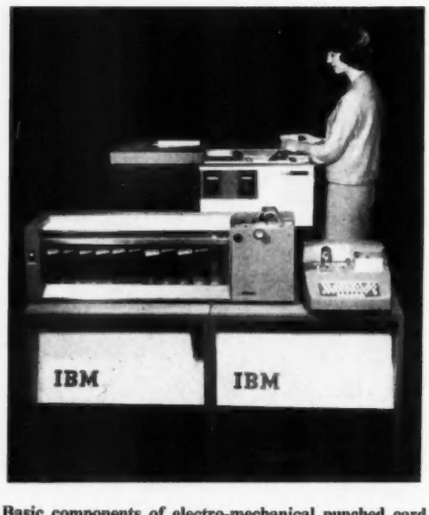
An alternative model (A493) of the unit illustrated is made in a vertical form which facilitates passing through doors. The vertical layout also brings the lower end of the moist air intake and dry air delivery grilles almost to floor level so that maximum effect is achieved in drying floors. It is recommended that two units of this kind should be used for drying out an average-size floor of large modern office blocks, the operation taking six days. The vertical dehumidifier is also mounted on castors for mobility. It measures 3ft 9in high by 1ft 8in wide by 3ft 3in deep.

The 105,000 cubic feet capacity of these units applies to regulation of humidity between 40 and 100 per cent. For automatic control down to 30 per cent the corresponding figure is 22,750 cubic feet, and for quick-drying of new buildings the capacity of a single unit is 17,500 cubic feet.

[Reply Card No. E1801]

Punched Card Accounting

WITH the object of extending punched card accounting to smaller organisations than have been in the habit of using it, a new and compact system, the IBM3000, has been introduced by IBM United Kingdom, Ltd., 101, Wigmore Street, London, W.1. The system comprises three basic units as illustrated, which are small and light so as to come within the normal loadings for upper floors of office blocks. The accounting machine itself, seen at the rear of the illustration, weighs some 860 lb as compared with weights in the region of 1 ton which are often met with. By combining the functions of reading, calculating, printing and punching in the same machine an important saving of space has been achieved. A further move in the same direction has been the combination of punching and verifying in the single keyboard seen on the right. A programme drum on the punch/verifier provides for automatic duplication or skipping of cards.



Basic components of electro-mechanical punched card accounting system for small firms

The card sorter seen next to the punch sorts cards into alphabetical or numerical sequence at 460 a minute. Impulses for controlling deflection into the sorting channels are derived from a sensing brush and amplified by transistor circuits.

The system uses an electromechanical store with simultaneous read-in and read-out during the machine cycle. Counting is by means of relays, and plug-in units are interchangeable for decimal or sterling counting. Certain calculating routines are covered by means of interchangeable plugboards which can be set up by the user. The machine operates at ninety cards a minute.

The latest addition to the system is a card interpreter which interprets and prints out on top of the cards themselves the numerical and alphabetical information contained in them. The interpreter operates at forty-five cards a minute.

Investigation of user requirements in punched card accounting has led the maker of this equipment to conclude that the system would be economic for manufacturing organisations with a payroll of 100 people. Commercial firms might find its use justified with lower numbers, and it is suggested that its application is worth study by such an organisation with a payroll of twenty-five.

[Reply Card No. E1802]

Weather Radar

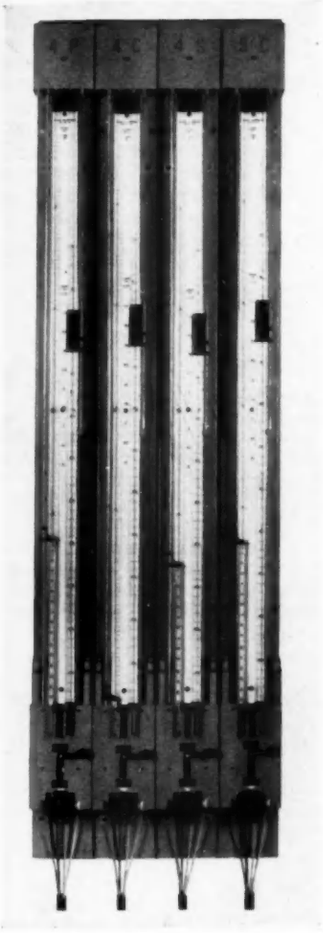
DETAILS of a new ground meteorological radar, C.R.353, have been received from Cossor Radar and Electronics, Ltd., Elizabeth Way, Harlow, Essex. This is a 10cm equipment formed of several units which can be assembled in various combinations to provide windfinding and other facilities. The basic windfinding installation comprises an 800kW transmitter-receiver, an aerial assembly, an indicator and control unit, and a data presentation unit. This assembly provides facilities for detecting and tracking a passive reflector carried by a free balloon. In its simplest form the windfinding operation is controlled manually by the operator from the indicator and control unit, by keeping two crossed pointers correctly positioned. Tracking in range is automatic. The three positional co-ordinates of the reflector are displayed on visual indicators on the data presentation unit. A timing unit provides pulses which " freeze " all indicators at regular intervals to facilitate plotting. At small stations plotting could be performed by the man who releases the balloon, the equipment being laid on target and kept thereon by one other man. Optional additions to this basic equipment are automatic target following in all three co-ordinates, automatic print-out from the data presentation unit, and a computer to convert the slant range and elevation co-ordinates into ground range and height co-ordinates.

To provide for weather observation, additional equipment is fitted to rotate the aerial continuously in azimuth while set at predetermined small angles of elevation, and echoes are displayed on a P.P.I viewing unit with a 12in screen. Cloud density determinations and cloud height estimations can be made. For cloud observations, iso-echo circuits suppress the response to pulses at a predetermined height and facilitate density comparisons. The same facility assists in accurately locating the " eye " of a storm. By these methods the cloud data obtainable compare with short-range observations by a 3cm radar while taking advantage of the range and penetration of the 10cm wavelength. The scanning mechanism can be programmed for any search pattern. Remote observation and control are possible, enabling the equipment to remain on weather surveillance between the spells of duty of the windfinding crew.

[Reply Card No. E1803]

Ullage Indicators

THE recently completed 48,500 tons deadweight oil tanker " Kent " owned by the Federal Steam Navigation Company, Ltd., has been equipped with the ullage measuring system developed by Dobbie McInnes, Ltd., and consisting of " Teledep " ullage indicators. The indicators are located in two centralised groups on the forward and aft ends of the midship deck-house, at bridge deck level ; and from these gauge positions the officer in charge of loading or discharging operations can easily supervise the opening and closing of the cargo valves. The system incorporates a device for checking and ensuring that the lines between the indicators and the cargo tanks remain in



" Teledep " ullage indicators

working order and free from faults. Over the last few feet from the crown of the tanks the ullages can be measured with an accuracy of about ¼in and ullages greater than this to something better than 1ft.

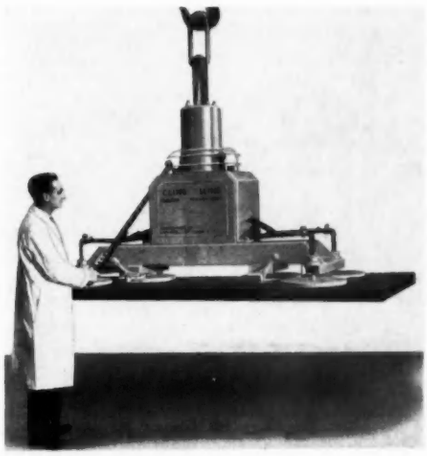
The introduction of the indicators, a group of which we illustrate, helps towards establishing a centralised control, system and from the commencement of loading they provide complete information of the progress of the filling operations by indicating which tanks are being filled and at what rate. Should a tank lag behind the others or should a wrong tank be connected to the filling line then this fact can be observed immediately. Use of the system enables the rate of loading to be found for a single tank, a group of tanks or for the whole ship, and eases the strain of loading under difficult conditions and when high rates of loading are demanded, especially towards the completion of the operation when care and accuracy are most important. By installing " Teledep " ullage indicators it is claimed that there is a saving of about three to four hours in the deballasting and loading time of a large tanker. The time for deballasting or discharge of cargo is reduced because the " Teledep " system gives continuous ullage information, so that the main pumps can continue on full load to a much lower level before changing over to the stripping pumps. The latter, since they are given less to do, can keep abreast of the higher rated main pumps. Furthermore, since the tanks are closed throughout the loading operation the fire risk is reduced. The system also reduces the risk of accidental overfilling and the accompanying structural damage, while the errors in final ullages are minimised.

[Reply Card No. E1811]

Vacuum-Operated Lifting Equipment

A VACUUM " lifting " equipment known as the " Cling-Sling " developed for use with cranes by G. D. Peters and Co., Ltd., Slough, Bucks, is designed to eliminate need for slings, ropes, chains, &c., when handling a variety of materials and manufactured goods. Suction pads on the underside of this equipment provide the " grip " on articles, and vacuum for this purpose is provided from an integral power pack, which evacuates a " reservoir."

The general design of a typical " Cling-Sling " is shown in the illustration below. The power pack can be installed separately on the floor but is usually, as shown, hung from a crane and arranged to carry a beam or beams fitted with a suitable array of suction pads. A vacuum reservoir of 2½ cubic feet capacity in



Vacuum lifting set with six suction pads fitted on a standard beam and having a capacity for loads up to 4000 lb

the power pack is connected through a non-return valve to an air exhauster driven by a ½ h.p. motor. A vacuum switch coupled to this reservoir cuts the exhauster motor in at 22in Hg and out at 23in Hg to maintain a minimum degree of evacuation whilst the unit is idling. During actual lifting operations a second switch in the manifold, described below, is effective.

The equipment is operated either through controls on a guiding handle, as shown, or duplicated controls at any remote station such as in a crane cab. Three control push buttons are provided on the handle, two of which are in parallel and are depressed to release the load, and one for applying the vacuum grip for lifting. These push buttons operate a magnetic pneumatic valve fitted in an air line between the reservoir and a manifold connecting the suction pads. This valve, actuated by a permanent magnet, is electrically inert when in the open and closed positions so that it only operates upon an electrical impulse being transmitted on depression of the " lift " or " drop " control buttons.

A further valve inserted between the main control valve and the manifold opens directly to atmosphere on depression of the " drop " push button to give a full flow of air to the suction pads and ensure speedy release of a load. When the lift control button is operated this direct admission valve is closed by the evaucation of a chamber behind its actuating diaphragm through a connection to the main pneumatic control valve. The direct admission valve assembly incorporates a micro-switch in parallel with the reservoir vacuum switch. By this arrangement, when the admission valve is closed the vacuum switch is cut out and the exhauster motor then runs continuously to draw air from the manifold and suction pads until the degree of vacuum attained is 18in Hg.

Two red signal lamps operated by a vacuum switch in the manifold are illuminated until this working vacuum, of 18in Hg is attained and then a green lamp is illuminated to show that the load is firmly held ready for raising by the pads. Until this safe vacuum of 18in is attained and maintained the green light will not be switched on. The manifold is fitted with two three-way connectors to which up to six suction pads can be fitted.

Suction pads are available to adapt the equipment for handling materials with flat, curved and other profiles, and these pads can be arranged on a number of alternative beam assemblies in sets to suit loads of various shapes, sizes and weights. Each standard suction pad consists of an iron disc some 19in diameter and fitted with an 18in diameter neoprene sealing ring which, when compressed, gives a nominal effective contact diameter of 17in for lifting purposes. With this 17in diameter contact and the working vacuum of 18in Hg the standard pad has a rated safe lift of 667 lb. A standard beam with its full complement of six pads has a rated lift of 4000 lb. The standard suspension, as shown in the illustration, consists of an elongated link attached to a bracket bolted to the reservoir head. A directionally stable suspension which can be provided consists of a beam bolted to the reservoir head. Two pulleys are mounted at the ends of this beam, and a wire rope passing round these pulleys is attached at one end to a crane crab and at the other to the crane hook.

In the event of an electrical supply failure whilst a load is suspended the green lights are extinguished, indicating that the load should be lowered at once. The reserve vacuum capacity of the reservoir is such that the load is not immediately dropped in this event. As the main control valve is held open by a permanent magnet it also remains in its effective condition in the event of an electrical failure.

[Reply Card No. E1812]

Indian News

ALUMINIUM PLANT TO BE ESTABLISHED

The Union Government has granted a licence to Madras Aluminium, Ltd., under the Industries (Development and Regulation) Act for the establishment of an aluminium plant at Mettur in Salem District, Madras State. This new undertaking, in the erection of which the Italian firm of Montecatini is collaborating, will have an installed capacity of 10,000 metric tons of aluminium ingots per annum, of which a third would be electrolytic type suitable for making conductors. The estimated cost of the project is Rs.10·3 crores, of which the foreign exchange involved is 4·43 crores. This is the first major aluminium plant in the Madras State. Both bauxite, the raw material, and electrical energy for its reduction to metal are found in close proximity. Bauxite comes from the Shevaroy mountain with at least 7,000,000 tons of ore with a quality of 50 per cent in the run-of-mine ore to some 60 per cent in picked pieces. With the inauguration of the Kundah hydro-electric project power supply for the plant has been guaranteed and a special 220kW line has been laid from Kundah to Salem and extended to Mettur.

INDUSTRIAL NEWS

The Common Market

The Federal Trust for Education and Research has issued a report of a two-day course held in October last year on "The Progress of the Common Market and its Effects on the United Kingdom." At the first session Mr. Carlo Hemmer and Mr. de Kergolet spoke on "The Community: Progress to Date and Prospects for the Next Five Years." This was followed by a discussion. The address at the second session was "A Survey of the Legal Position as to Agreements and Arrangements between Firms in Member States of the Community"; the speaker was Mr. John Bowyer. At the third and last session on the first day the speakers were Mr. P. C. Millson, "A Survey of Agreements and Arrangements in Member States of the Community," and Mr. C. G. E. Parrott and Mr. H. W. Vallender, "The European Trade Associations."

At the first session on the second day Mr. E. Russell Eggers spoke on "United Kingdom Penetration of the Community Market." The second and final session took the form of a panel discussion on "The State of Things to Come: the Future of United Kingdom Relations with the European Communities."

The next similar course to be held by the Federal Trust will take place on May 18 and 19, and will deal primarily with the European Free Trade Association.

Export Guide

The eighteenth issue of the *G.E.C. Export Guide*, a quarterly publication designed to help manufacturers and traders by giving them information about opportunities in international trade, appeared on January 23. This guide, which is now in its fifth year of publication, covers thirty-six groups of manufactured goods exported to Great Britain's thirty-four major overseas markets. Each of the thirty-six product groups charted in the *Guide* makes a contribution to British exports of at least £14,000,000. In 1960, for example, the *Guide* recorded one-third of all British exports and 63 per cent of the exports to the thirty-four main British markets overseas.

The choice of the thirty-four markets is governed by the simple statistical criterion that the *Guide* should include any country that imports from Great Britain goods worth more than £20,000,000 per annum. Major market changes are therefore reflected in the *Guide* and the next issue, to be published in April, will include Japan for the first time—a sign of the growth in her trade with Great Britain.

The *Guide* is in the form of a grid showing changes and trends of each product group in each country. In addition a number of general economic indicators (outlook for British exports, industrial production, economic activity and prices) are charted for each country. Changes are recorded on the grid by means of symbols based on percentage movements. In the case of the economic indicators the minimum percentage of movement justifying a recorded change is 4 per cent. The percentage swing needed to change the product group indicators varies with different commodities. For instance, typical minimum swings to justify a change on the grid are as follows: iron and steel bars 20 per cent increase and 15 per cent decrease; mechanical handling equipment 30 per cent increase and 23 per cent decrease; ships and boats, 50 per cent increase and 33⅓ per cent decrease. These values represent the compilers' judgment of changes that should be regarded as significant.

Each issue of the quarterly *Guide* (January, April, July, October) goes to 15,000 recipients. Nearly half the copies are taken by the manufacturing industries in Great Britain—just under 20 per cent by the engineering industries (excluding electrical engineering). The textile industry take over 8·5 per cent and the electrical and chemical industries take over 4 per cent each. Export merchants take 22 per cent of the total, so that industry and commerce combined account for nearly three-quarters of the circulation. For the rest, government departments, British and overseas, take 6 per cent of the total and educational establishments 3½ per cent.

Overseas Trade

The final figures issued by the Board of Trade for United Kingdom trade in 1960 show that exports were valued at £3536 million, imports at £4556 million, and re-exports at £141 million. The value of exports in 1960 was £206 million or 6 per cent higher than in 1959, the increase in volume being about 5 per cent. Imports were £573 million or 14 per cent more than in 1959, the increase in volume being about 13 per cent. Re-exports in 1960 were valued at £10,000,000 more than in the previous year.

Discounting normal seasonal variation, the Board says, the quarterly export figures show a rise of 4 per cent in the first quarter of 1960, falls of 3 per cent and 2½ per cent in the second and third quarters and an increase of 2 per cent in the fourth quarter. Monthly export figures were remarkably stable during the year, the Board adds, but this stability in the total conceals considerable divergencies between exports of different types of goods and exports to different markets. Growth in exports of a wide variety of products, particularly non-electric machinery, was balanced by a sharp fall in exports of cars and substantial falls in exports of iron and steel and non-ferrous metals. Imports increased very rapidly in the second half of 1959 and at a lower, though still substantial, rate up to the final quarter of 1960

By commodity groups, the Board points out, one-half of the increase in United Kingdom exports between 1959 and 1960 was due to a rise of £104 million, 7 per cent, in exports of engineering products, exports of non-electrical machinery (other than aeroplane engines) contributing £76,000,000 to this figure. There were increases of the order of 20 per cent or more in exports of agricultural tractors, excavating machinery, machine tools, and office and textile machinery, but all these items were showing smaller increases over a year earlier in the final quarter. Exports of electric machinery and appliances rose only slightly between the two years. Exports of scientific instruments increased by 14 per cent between 1959 and 1960 with a similar increase during 1960. The exports of cars and chassis during the year showed no increase on 1959. Exports of commercial vehicles rose by 18 per cent in 1960 and were valued at £102,800,000. Exports of ships and boats were 9 per cent greater than in 1959. Exports of railway vehicles fell for the second year running and were valued at only £20,400,000. Airframe exports during 1960 were 28 per cent less than in 1959 and were valued at £61,800,000. Exports of new aeroplane engines rose by 21 per cent to £30,700,000. whilst exports of used engines dropped by 6 per cent to £21,800,000. (The total of £52,500,000 for engines does not include the figure of £21,100,000 for parts.) The recovery in exports of iron and steel in the latter part of 1959 continued into 1960, the Board states, and there was an increase of 12 per cent in value between the two years. Exports of non-ferrous metals were 13 per cent below the total for 1959.

Industrial Psychology

The National Institute of Industrial Psychology has this week published its annual report and statement of accounts. The institute is now making use of electronic computers to analyse some of its latest research findings and reports on the result of two such inquiries will be issued shortly. One of these inquiries deals with the relationship between workers' satisfaction with their jobs and the efficiency with which they do them. The other is concerned with workers' views on the relative desirability of certain personal attributes, like ambition and education, in industrial employment. In the study of hopes and aspirations of occupational significance, data have been obtained during the year from 450 school-leavers about what they expect and hope for from their future jobs. This material is being analysed, the report says, to develop a clear descriptive framework for the pursuit of the inquiry and to trace formative influences on young people's aspirations for their future. During the year under review the institute has also been studying the attitudes of employees to having their company taken over by another, and a report on this is to be issued in the near future.

The report also mentions successes with attitude surveys. In these surveys, investigators hold a series of confidential interviews with employees, including supervisors and managerial staff, to find out what they think is wrong with the organisation and how it could be put right. The investigators make recommendations for action to the management on the basis of what is discovered.

During the year, the report says, 708 people, the great majority of them boys and girls of school-leaving age, have been given advice about the choice of a career. Work has also continued on the follow-up of vocational guidance cases conducted in the years 1947 to 1950. The institute undertakes to advise employers on the suitability of cadidates for specific posts, and during the year advice on selection has been given to thirty-seven firms, in the course of which 197 candidates have been tested and interviewed.

PERSONAL AND BUSINESS

Appointments

MR. W. M. CHAPMAN-WALKER has been appointed a director of Aerialite, Ltd.

MR. J. S. CLEMO has been appointed to the board of The Benjamin Electric, Ltd.

MR. F. SARGEANT has been appointed managing director of Woodfield Rochester, Ltd.

DR. W. S. WALKER has joined Campbell, Gifford and Morton, Ltd., consulting engineers.

SIR PHILIP SOUTHWELL has been appointed a director of The Cementation Company, Ltd.

MR. T. K. SINGER has been appointed general sales manager of James Booth Aluminium, Ltd.

MR. R. H. HAZLEHURST has been appointed Midlands area representative of Lumenated Ceilings, Ltd.

MR. J. M. HARRIS has been appointed managing director of Holland & Hannen and Cubitts (Great Britain), Ltd.

MR. RICHARD WYATT, sales manager of Tunny Cranes, Ltd., has been appointed sales director of the company.

MR. RONALD G. HOOKER has been appointed deputy managing director of K. and L. Steelfounders and Engineers, Ltd.

MR. JAMES WINSTANLEY, A.M.I.Loco.E., has been appointed general overseas manufacturing manager of F. Perkins, Ltd.

SHELL-MEX AND B.P., Ltd., states that Mr. D. H. F. Joyce has been appointed manager, supplies and distribution department.

MR. B. A. THURGOOD has been appointed resident director of George Cohen Australian Scrap Company Proprietary, Ltd., Sydney.

MR. F. J. B. BARRY has been appointed commercial manager of The General Electric Company, Ltd., Engineering Works at Witton, Birmingham.

LONDON MIDLAND REGION, BRITISH RAILWAYS, announces that Mr. W. F. Beatty, new works officer, London, has been appointed assistant civil engineer, Euston.

MR. P. F. J. TROLLOPE, A.M.I.Mech.E., M.I.Mar.E., has been appointed to the board of Hawker Siddeley Brush Turbines, Ltd., with the title of works director.

MR. A. ELLIOT, export manager for Baird and Tatlock (London), Ltd., has been appointed general sales manager of the associated company, W. B. Nicolson (Scientific Instruments), Ltd.

MR. J. HENDERSON, M.I.Mech.E., M.I.P.E., has been appointed general works manager of C. A. Parsons and Co., Ltd., in succession to Mr. W. Winter who retired on December 31, 1960.

MR. LAURIE DENISON has joined the staff of the Castrol Group. He will be posted to the Group's associate company in Brazil, Castrol (Lubrificantes) S.A., as technical consultant on industrial oils.

SIMONS-LOBNITZ, Ltd., states that Mr. H. Pearson Lobnitz has announced his intention to retire and is resigning as managing director with effect from February 28. Mr. J. H. Spurr has been appointed to succeed him as managing director.

MR. C. H. GRIST, deputy chairman and managing director of Blaw Knox, Ltd., and chairman of Blaw Knox Chemical Engineering Company, Ltd., has been elected president of the Federation of Manufacturers of Construction Equipment.

BAILEY METERS AND CONTROLS, Ltd., announces that Mr. Ll. Young, M.I.Mech.E., M.I.Mar.E., has been appointed director of the company. He has assumed the position of director of engineering and has relinquished the position of general manager.

THE CHAMBER OF SHIPPING OF THE UNITED KINGDOM announces that at a council meeting held on January 26, Mr. W. Errington Keville was nominated as President for the ensuing year and Mr. David M. Robinson was nominated as Vice-president.

THE MINISTRY OF AVIATION announces that Mr. D. E. Morris, chief superintendent of the Royal Aircraft Establishment at Bedford, has been appointed director-general of Aircraft Research and Development (R.A.F.) in succession to Mr. L. Boddington who has resigned from the public service.

MR. J. L. DELL has been appointed chief test pilot of English Electric Aviation, Ltd., in succession to Mr. R. P. Beamont who has taken up his new post as deputy chief test pilot of British Aircraft Corporation. Mr. Beamont will continue to be manager of flight operations and a special director of English Electric Aviation, Ltd.

PRECISION GEAR MACHINES AND TOOLS, Ltd., announces the following appointments: Mr. D. E. Banham joins the company as works manager, the appointment becoming effective from February 13; Mr. Terence G. Coombs has joined the company as management accountant; Mr. John G. H. Shiach has been appointed plant engineer; and Mr. John B. Hall, A.M.I.Mech.E., has joined the company as production controller.

THE GOODYEAR TYRE AND RUBBER COMPANY (GREAT BRITAIN), Ltd., announces that Mr. P. F. Kavanagh has been appointed assistant divisional manager, Scottish division, in Glasgow. The company has also announced the appointment of Mr. E. G. Smethurst as manager of the north western sales division, which has its headquarters in Manchester. He replaces Mr. E. D. Mackintosh, who has been transferred to head office at Wolverhampton.

KESTNER EVAPORATOR AND ENGINEERING COMPANY, Ltd., states that coincident with the retirement of Mr. J. Arthur Reavell, M.I.Mech.E., M.I.Chem.E., from the chairmanship of the Group and his appointment as president, the following changes have been made in the board: Mr. B. N. Reavell, M.I.Mech.E., M.I.Chem.E., has been appointed chairman; Mr. G. H. Black, managing director; and Mr. C. A. Pither, director and secretary, on the retirement of Mr. W. S. Knight, after 47 years as director and secretary. Mr. J. W. Grose, A.M.I.Chem.E., continues as an executive director.

SIMON ENGINEERING, Ltd., announces the following appointments and changes in organisation: Mr. D. T. Barritt has been appointed deputy chairman. Owing to ill-health Mr. I. Hey will relinquish the chairmanship of Henry Simon (Holdings), Ltd., on March 1, 1961, but will remain a director of the company. Mr. D. T. Barritt has been appointed a director of Henry Simon (Holdings), Ltd., and will take up the appointment of chairman of the company on March 1, 1961: he will relinquish his executive responsibilities and his appointment as joint managing director of Simon-Carves, Ltd., from the same date; he will, however, remain a director of Simon-Carves, Ltd. Mr. J. P. V. Woollam was appointed deputy chairman of Simon-Carves, Ltd., on December 12, 1960. Mr. L. Brook has been appointed a director of Simon-Carves, Ltd., and a member of the management board. Mr. A. H. Bennett has has been appointed a director of Henry Simon (Engineering Works), Ltd. Mr. J. G. MacLean has been appointed a director of Turbine Gears, Ltd.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the following changes in its overseas organisation. Mr. C. Murray, general overseas manager, is responsible for the operations of the overseas organisation and the co-ordination of its activities overseas. Mr. C. A. Chidwick has become overseas manager, responsible for all B.I.C.C. activities in Africa, the Middle East and the Near East: he will deputise for Mr. Murray in his absence. Mr. G. C. Knight has become overseas manager with responsibility for all B.I.C.C. activities in Australia and New Zealand; Canada and the United States; Central America; West Indies and South America; and Spain, Portugal and Gibraltar. Mr. A. F. Coventry has become overseas manager with responsibility for B.I.C.C. activities in Europe (excluding Spain, Portugal and Gibraltar), India, Pakistan and Ceylon. Mr. J. L. Woollett has become regional manager for Canada and U.S.A., responsible to Mr. Knight; and Mr. W. F. North, while continuing as secretary of the Telegraph Construction and Maintenance Company, Ltd. (Telcon), and Selborne Plantation Company, Ltd., and as general manager of Telcon Enterprises, Ltd., has become personal assistant to Mr. Murray.

Business Announcements

MR. C. E. POYNTER announces that he has resigned from the board of Weatherley Oilgear, Ltd., after twenty-three years' service. He will no longer be with the company after February 15.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its eastern regional staff is now operating from premises at Friars Walk, Friars Place, Chelmsford, Essex (telephone, Chelmsford 58171/2).

THE UNIVERSAL ASBESTOS MANUFACTURING COMPANY, Ltd., and THERMO PLASTICS, Ltd., a member of the Tootal Group, have formed as equal partners, a new manufacturing company, Allied Structural Plastics, Ltd.

THE UNITED STEEL COMPANIES, Ltd., announces that it has acquired G. R. Turner Ltd., of Langley Mill, Nottingham. It will be controlled in future by United Steel Structural Company, Ltd., a United Steel subsidiary.

Contracts

BRISTOL SIDDELEY ENGINES, Ltd., has received a contract for a third 3MW generator with a "Proteus" gas turbine from the South Western Electricity Board; it will be installed at Porlock, Somerset, controlled via the public telephone lines from Bristol.

PLOWRIGHT BROTHERS, Ltd., 197, Knightsbridge, London, S.W.7, announces that its Industrial Plant and Buildings Division has received an order for a 100 metric tons wagon traverser from Associated Portland Cement Manufacturers, Ltd. This traverser is to be installed at the Vallejo packing depot of La Tolteca, Compania de Cemento Portland, S.A., in Mexico.

THE MITCHELL CONSTRUCTION COMPANY has been awarded a contract for civil engineering works for the Manshead tunnel scheme of the waterworks department of the City of Wakefield Corporation. The value of the contract is in the region of £210,000, and it includes the construction of 8,000ft of tunnel, inlet and outlet works, including culverts, weir and gauge basins and ancillary works.

BRITISH AIRCRAFT CORPORATION, Ltd., has received from the Government of Ghana a contract for three Vickers VC-10 airliners. The virtue of this machine is its airfield performance, a runway length of 7400ft being predicted at an all-up weight of 299,000 lb. Ghana Airways claims that it will in time have the most modern jet and prop-jet fleet in Africa; it recently acquired Il-18 medium-range airliners.

THE COVENTRY GAUGE AND TOOL COMPANY, Ltd., announces that Mr. John M. Brice, Divisional Director, and Mr. D. G. Walder, Russian-speaking member of the Export Department of the company, recently returned from Moscow, having negotiated a contract valued at over £250,000 for the supply of thirty-four "Matrix" precision thread, gear and jig grinding machines. The company states that this is the second large order secured in recent months from the U.S.S.R. in the face of very keen competition from German and Swiss manufacturers. The total value of "Matrix" machine tools involved in these orders is now in excess of half a million pounds.

CAMMELL LAIRD AND CO. (SHIPBUILDERS AND ENGINEERS), Ltd., has received from Cable and Wireless, Ltd., an order to build a new diesel-electric cable-laying ship of about 8000 tons gross, at a cost of about £1,900,000. It will be the first British cable-laying ship originally designed to lay and handle modern deep-sea communications cables with repeaters, including the kind to be used in the 28,000 mile Commonwealth round-the-world telephone cable. The electric propulsion machinery and diesel engines will be built by the English Electric Company, Ltd., and the forward cable gear by Johnson and Phillips, Ltd. The new ship, the first cable-layer to be owned by Cable and Wireless, Ltd., will join the fleet of seven cable repair ships in the summer of 1962. It will have a maximum speed of 16 knots, with a steaming range of 8000 miles and a sea endurance of sixty days; overall length about 466ft and breadth 58ft 6in; carrying capacity 1200 miles of lightweight coaxial telephone cable with repeaters, or 1500 miles of conventional telegraph cable. There will be two funnels abreast, to allow the extensive cable working spaces to run through the superstructure without obstruction, facilitating cable work at either bow or stern. The ship will be fully air-conditioned for work in tropical waters and in colder climates.

Death

We record with regret the death of Lt. Col. G. S. Marston, M.I.E.E., who died in hospital in London on January 22. He was born at Bournemouth on June 7, 1892. Lt. Col. Marston received his early training as an engineer with Siemens at Stafford. He was co-founder of J. G. Statter and Co., Ltd., switchgear manufacturers of Amersham, Buckinghamshire: the company is now a member of the Metal Industries Group. In 1956 J. G. Statter and Co., Ltd., became part of the Lancashire Dynamo Group and subsequently Lt. Col. Marston became chairman and managing director of Lancashire Dynamo Holdings. He held that position until the group was merged with Metal Industries Ltd., early in 1960.

CONTINENTAL AFFAIRS

by Our Continental Editor

French "Bulb" Sets for Tidal and Low Head Power

No. II—(*Concluded from page 148, January 27*)

Last week an explanation was published of the theory of operation envisaged for the Rance tidal power scheme, and of the early development work for the turbo-alternator sets for the scheme. Our article concludes with a description of the prototype 9MW set installed at St. Malo, and of the "bulb" set for low-head generation at Beaumont-Monteux.

THE St. Malo bulb set was installed at the end of 1959 at a disused lock at the harbour of St. Malo when sufficient tide-locked "pondage" was available to run trials up to a maximum head of 5m (i.e. the head is sufficient to run the set at full load in pumping and generating modes) so as to ascertain the efficiencies of the machine for its various modes of operation, to assess generally its behaviour and reliability in actual use, and to gain experience of its operation and maintenance and of factors such as the corrosive effect of salt water.

The folding inset facing this page is a sectional drawing of the set, which shows its construction in some detail. It will be appreciated that certain special arrangements have been made in installing the set to achieve the most convenient experimental layout for the tests, even though electrical power is supplied to the grid. The main differences which should be noted between it and the future Rance power station are (*a*) there will be no sluice gates controlling the turbine culverts in the Rance station, (*b*) the turbine runners will face seawards in the Rance station (i.e. the sets have "upstream" bulbs) which is the reverse of the St. Malo arrangement which was adopted to get a larger head in the "inverse" turbine mode and (*c*) the cooling air circulating in the bulb will be at a pressure of 2 kg per square centimetre (absolute) thus enabling the output of the set to be increased to 10MW in the production version.

The set is required to operate (*a*) as a turbine or (*b*) as a pump or (*c*) as a sluiceway, in both directions of flow for all three modes, i.e. it has six modes of operation, but the range of heads varies as between the different modes as shown in the table. This multi-purpose operation is achieved with a four-bladed horizontal-shaft turbine, whose blades are adjustable in the manner of a Kaplan turbine. Flow to this turbine from the "bulb" side is directed by a set of fixed guide vanes, and then, closer to the turbine, a set of movable guide vanes. The diameter of the turbine runner is 5·8m. The nominal output of the set is 9MW under a head of 5·5m; the nominal flow through the set under these conditions is 270 cumecs. Further data are given in the table.

The principal elements of the set are: the hydraulic culvert surrounding the "bulb" and turbine; the upstream ogee or cone; the thrust bearing and the spider which carries it; the alternator; the "upstream distributor" or stay ring with fixed guide vanes; the "downstream distributor" with movable guide vanes; the turbine "cone"; the turbine runner; and the shaft. All of these elements are clearly distinguishable on inset drawing.

There is a deceptive simplicity about the appearance of the set, which is the more obvious when the earlier layouts—one of them with two turbine runners—are recalled. The St. Malo set was designed with the basic aim of developing a turbine blade of a shape such that acceptable efficiencies would be achieved in the machine in its various modes of operation and over the ranges of heads required, with only limited angular adjustment of the blades. With this achieved, relatively simple and reliable mechanisms, already proven in Kaplan turbine practice, could be utilised in constructing the servomotor of the turbine, space-saving and reliability being equally important considerations.

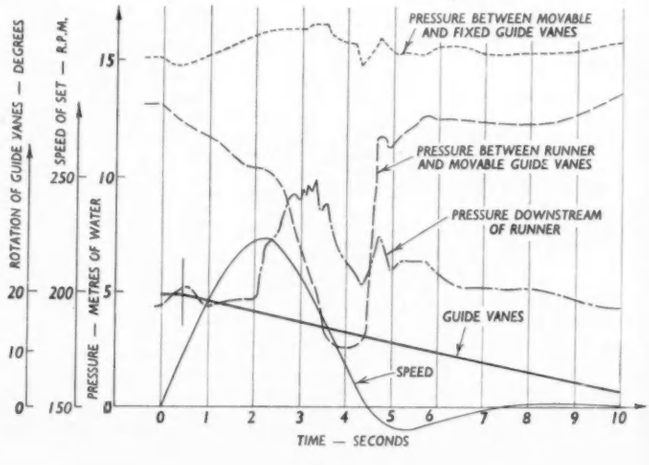
TABLE I—*Principal Data for St. Malo Bulb Set*

Nominal output	9MW
Generating conditions	5·6kV, three-phase, 50 c/s cos $\phi = 1$
Speed	88·2 r.p.m.
Operation as turbine:	
Maximum head	11m
Minimum head	5·5m
Nominal flow for 9MW output at maximum head	100 cumecs
Nominal flow for 9MW output at minimum head	270 cumecs
Operation as a pump:	
Maximum pumping head	6m
Minimum pumping head	−1m
Capacity at maximum pumping head	300 cumecs
Capacity at minimum pumping head	70 cumecs
Operation as a sluiceway:	
Cross sectional area as open sluice	30 square metres
Range of heads for operation as a sluice	0–3m
Capacity at 1m head	186 cumecs
Capacity at 3m head	322 cumecs
Overall length of bulb	15m
Principal diameter of bulb	5m
Maximum diameter of annular culvert	9m
Diameter of runner	5·8m
Total weight of "monobloc" assembly	400 tons
Level of centre line of set	+3m
Permissible range of water levels in dock	+10·5m to +12·5m
Water area of dock	65 hectares

Each blade of the St. Malo turbine is almost symmetrical in profile, and shaped as a letter "S." The range of adjustment of the turbine blades is 45 deg. This may be compared with the range of adjustment of 230 deg. of one of the Cambeyrac turbines, necessitating a relatively enormous and complicated servomotor and "bulbs" both upstream and downstream of the turbines. We understand that both theory and model testing played their part in evolving the blade form, but model testing has been the dominant method.

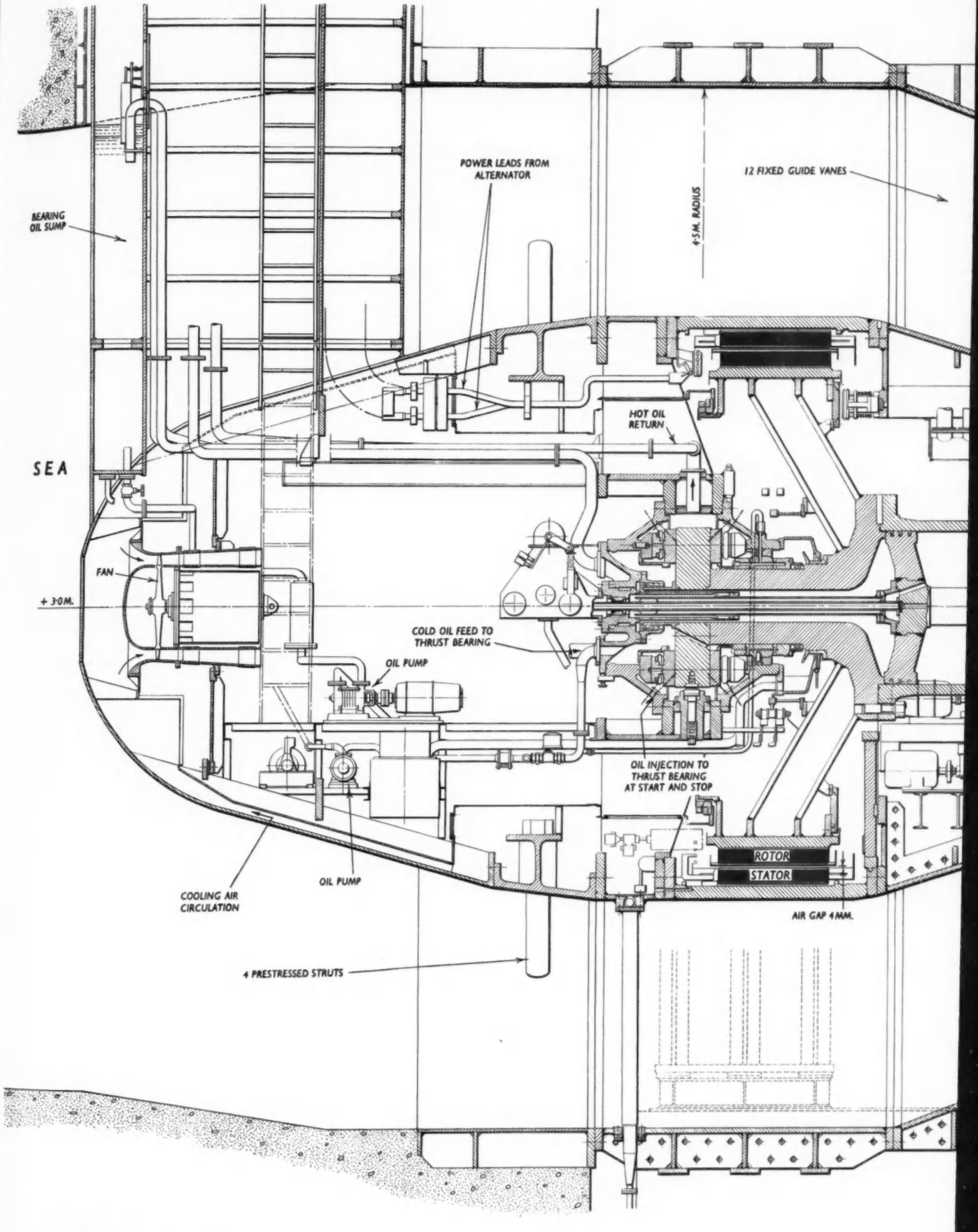
Another important problem was that of runaway, "bulb" sets with their relatively low inertia and rapid starting time, being in principle more vulnerable to runaway conditions than conventional vertical-shaft Kaplan sets. Furthermore, it is considered that the provision of sluice gates or valves, and also of screens, would be too cumbersome and expensive in a tidal power station where these sets are to be installed. A special study of runaway speeds and hydraulic conditions at runaway, was thus an essential step in design. A typical example of throwing the St. Malo set off load at 2600kW is shown in the diagram. Closure of the adjustable vanes is approximately linear, and is completed 3·5 seconds from the moment of tripping the load; then the vanes are opened at about 4·5 seconds, and reclosed afterwards. Note that the pressure between the runner and the vanes decreases rapidly and at one point the hydraulic thrust reverses. These conditions are similar to runaways in normal vertical-shaft Kaplan sets, but are potentially more dangerous, and a partial dewatering of the turbine runner must be avoided at all costs, the makers state, since appreciable alternating loads on the runner blades, and alternating bending moments on the shaft, would result. They point out that such conditions can be avoided by "appropriate devices" and it is considered that this problem has been satisfactorily solved. Emergency operation involving adjustment of the runner blades alone, or alternately of the movable guide vanes alone is feasible.

These same characteristics show that in principle bulb sets are not suitable for installation where frequency regulations of the network which they serve is needed, unless some complementary devices, such as synchronous compensators are installed with them, or unless speed-increasing gearing is added between the turbine and alternator as in the case of the "pier-type" set. But the small dimensions of the bulb have other advantages. In the case of the Rance scheme, it means that sufficient sets can be installed to give the required capacity for a limited length of barrage, and in the general case, it implies a reduction in civil engineering costs.

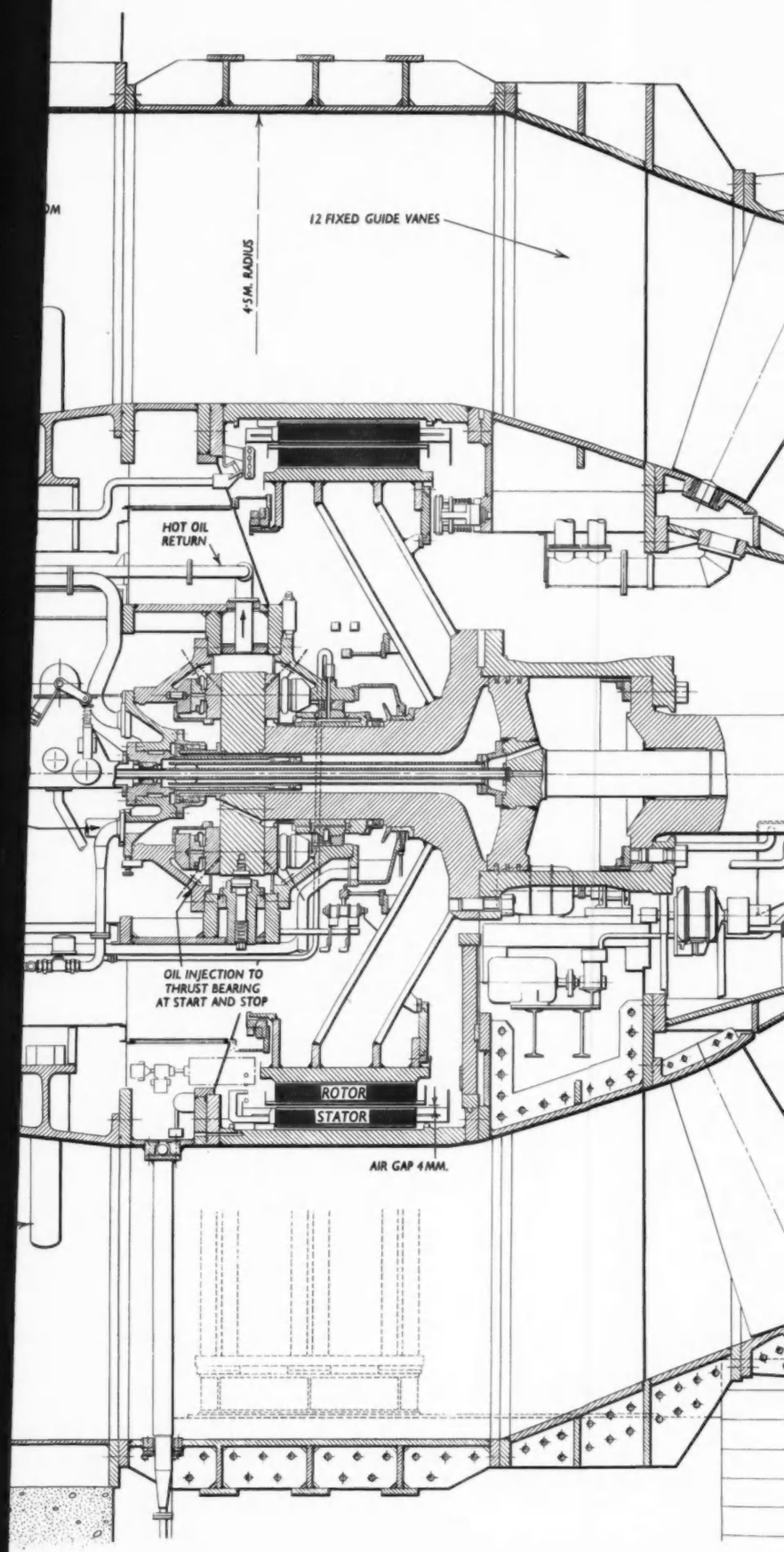


Runaway at 2600kW under 11m head

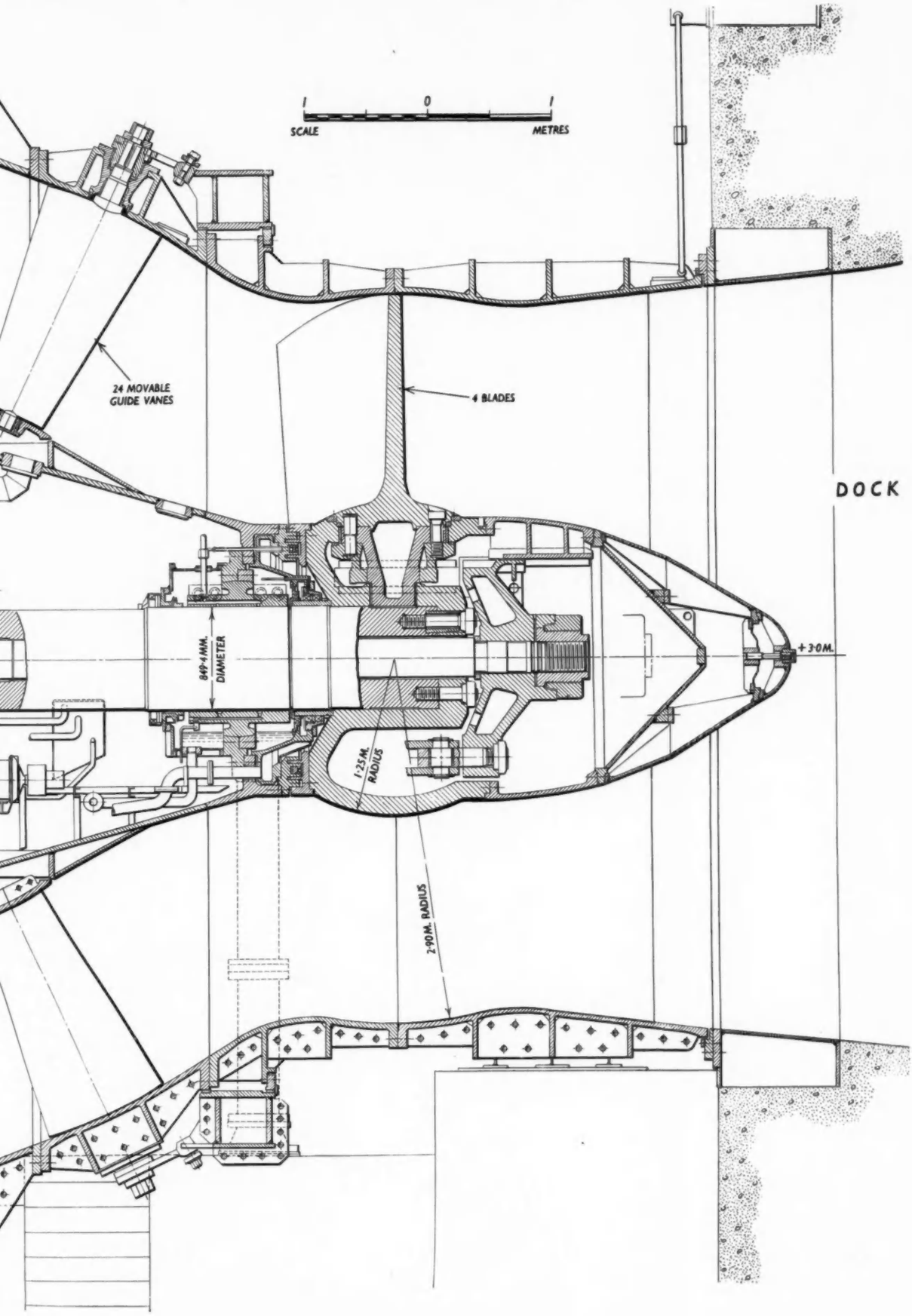
PROTOTYPE "BULB" SET OF 9MW FOR TI



SET OF 9MW FOR TIDAL PO



POWER GENERATION AT ST. MALO



Design of the movable guide vanes also presented special problems, as did the thrust bearing ; by contrast, the alternator is largely conventional, the problem here being one of restricted space. The fact that guide vanes are provided on one side of the turbine only is also a noteworthy point. This is clearly in the interests of simplicity, and is influenced by the fact that more power is generated in the direction of flow towards the sea, than in the reverse direction, so a slightly lower efficiency is acceptable in the latter case.

The Culvert.—The annular culvert around the bulb which converges to enclose the turbine runner is built up of elements of steel, which are largely bolted together. In contrast to the Beaumont-Monteux set, only those lining rings at the extreme ends are cast into the surrounding concrete. The structural loads of the bulbs which are carried through the fixed guide vanes are distributed thence through the steel lining of the conduit to pedestals in the lower part of the " sump " shown surrounding the culvert lining.

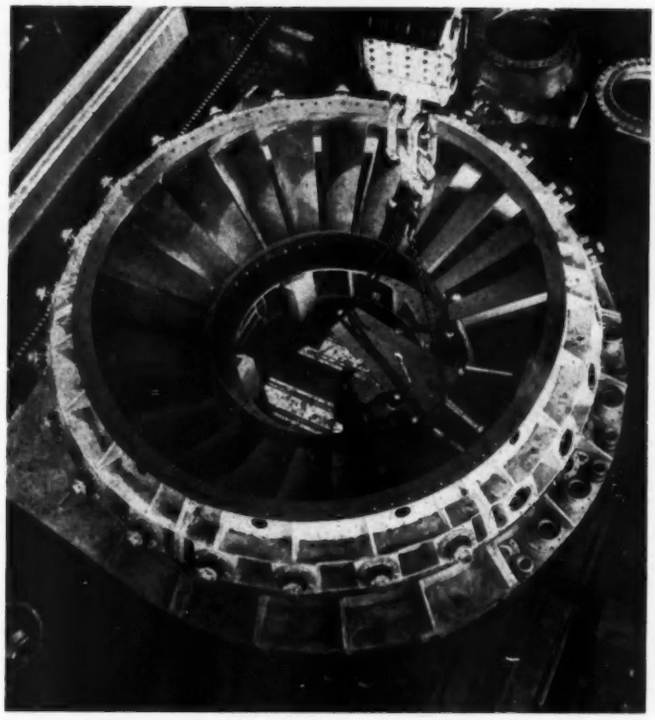
Stainless steel is used extensively, and cathodic protection is also utilised in the construction of the bulb and culvert.

The Upstream Ogee.—This is the name given to the steel shell forming the upstream side of the bulb. The skin is largely of stainless steel for it is used for cooling the air circulating through the alternator It can be dismantled rather simply, being held in position by four prestressed strut and tie assemblies, placed at 45 deg. to the axis of the set, and by a strut placed vertically below its centre line. Note the fan and air circulation around the alternator and along the skin of the ogee. Circulation of air is at atmospheric pressure. A streamlined shaft, which can also be dismantled, gives access to the top of the ogee ; it contains the various cables and pipes serving the interior of the " bulb," and also the tank (with cooling surfaces on the upstream) for the bearing oil.

The Thrust Bearing.—This assembly consists of the thrust bearing proper, with a pivoted pad or self aligning bearing next to it. As we have already noted, the thrust bearing has been the subject of a special study, but its construction is nevertheless typical in some ways of Neyrpic practice, and it incorporates features resulting from a general study of the performance of large thrust bearings which the company has recently carried out. The most noteworthy feature is an arrangement which ensures automatically that the thrust is evenly distributed and thus a constant bearing pressure is ensured. Referring to the inset drawing, it will be seen that there are two sets of pads, resisting thrust in each direction respectively. Each pad is attached to a toroidal membrane of thin steel which is flexible, and which is bolted to a ring, the latter transmitting the load from the pads to the spider which supports the whole bearing, and which, in its turn, is carried by the shell of the bulb. Holes pierced in the ring interconnect the spaces inside the toroids, forming a sealed system which is filled with oil. Thus the pressure in each of the toroids is identical ; deformation of the steel membrane itself requires only a very small force in relation to the total load carried by the pad, and thus the distribution of load is quasi-perfect, variation being only of the order of a few per cent, it is claimed, even if manufacturing and assembling tolerances are exceeded. Similarly, the bearing is insensitive to deflection of the spider.

Oil is injected between the rubbing surfaces of the bearing when the machine is started or stopped, to ensure that the hydrodynamic film of oil between thrust pad and shaft collar is established rapidly, on the one hand, or maintained as long as possible on the other. In normal running, oil is circulated through the bearing by a pump, to the cooling surfaces of the oil tank on the ogee of the access shaft. The maximum thrust carried by the bearing is 350 tons.

The Alternator.—As already mentioned, the alternator is largely conventional, yet arranged as compactly as possible. The stator is carried directly on the skin of the bulb, and the rotor is welded to the shaft. Excitation is arranged outside the bulb as for the Beaumont-Monteux set. Cooling is by circulation of air round the bulb, as already noted.



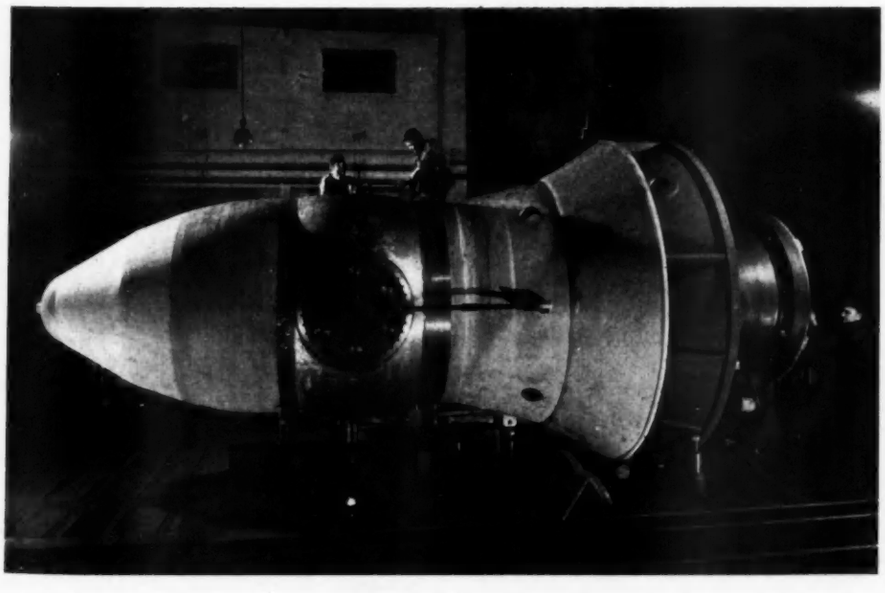
Fitting one of the adjustable guide vanes to the " downstream distributor " of the St. Malo " bulb " set at the makers' works

The Speed Ring.—The " upstream distributor," that is to say the assembly comprising the fixed guide vanes, is robustly constructed since the fixed vanes are also the principal structural support for the bulb, and in particular they transmit all horizontal thrusts from the bulb. Their construction is shown in the inset drawing.

The " downstream distributor," that is the ring of adjustable guide vanes, is illustrated. Adjustment of the vanes is effected at their outer ends (i.e. outside the bulb), by a series of links, each attached at one end to its vane and at the other to a regulating ring positioned vertically around the outside of the turbine conduit. Movement of the regulating ring is controlled by two oil servomotors and this mechanism is thus not unlike conventional turbine practice. However the guide vane design was complicated by the fact that when the guide vanes are on the downstream side of the runner in relation to the mode of operation, and in particular when the mode is that of pumping, turbulent flow leaving the tips of the turbine blades impinges on the vanes. To avoid vibration therefore, the vanes are of robust proportions and the vane control system is hydraulically locked for this mode, and also when the machine operates as an open sluice. There are twenty-four guide vanes, each 1·82m in length.

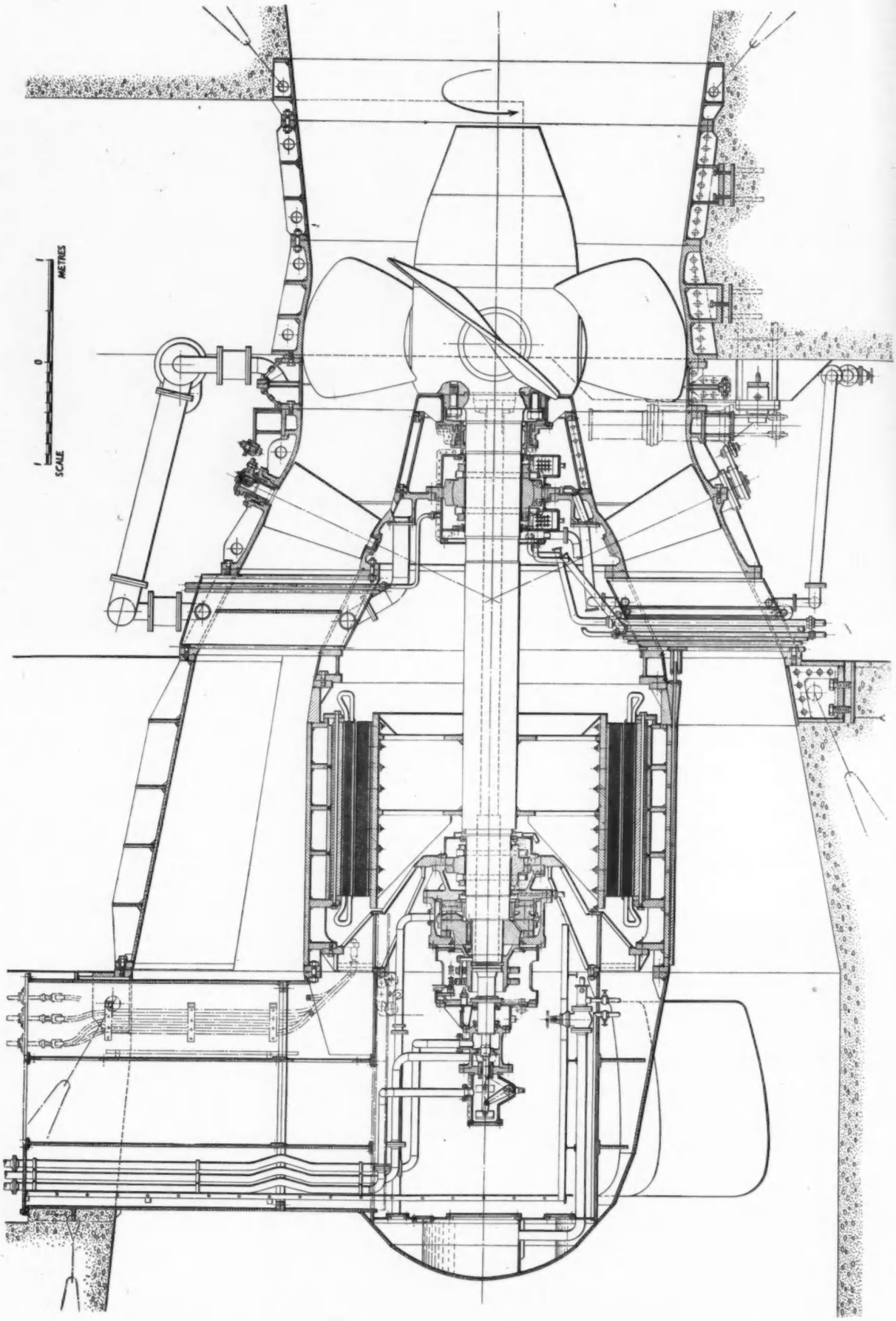
The Turbine.—Of the last of three amongst the principal components we have listed, namely the turbine " cone," the runner, and the shaft, little more need be said. The turbine " cone " carries the second of the shaft bearings and the carbon seals next to the runner. The runner is overhung from this second bearing ; apart from the specialised nature of its blade profile, its design follows accepted practice.

The servomotor is described as of " telescopic " design, which is best explained by reference to the drawing. The telescoping action over the tube



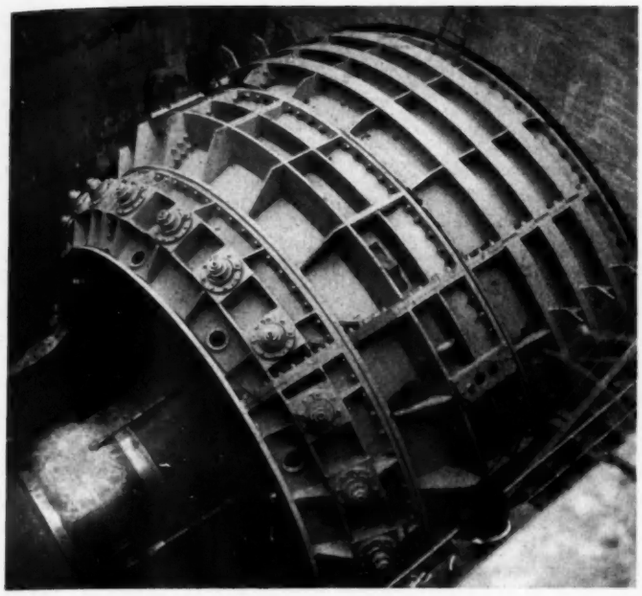
The turbine runner and the turbine " cone " of the bulb, arranged for transport (the runner blades are not fitted) at the maker's works

8·8MW LOW-HEAD "BULB" SET AT BEAUMONT-MONTEUX ON THE ISERE RIVER



inside the shaft (the tube does not rotate) can be clearly seen. The servomotor is drawn at the upstream limit of its travel. The servomotor is designed so that, during assembly, the cylinder can be slid along the turbine shaft to facilitate connection of supply piping to the cylinders before the turbine is coupled to the alternator.

Test results concerning the blade operating forces have not yet been analysed but similar tests performed on the Cambeyrac set show that these forces are similar to those experienced with conventional Kaplan turbines.



Above : The exterior of the annular culvert largely in position, with the turbine "cone" still visible. Right: The "bulb" from upstream. The upstream ogee is resting on the invert, but the four prestressed struts to which it will be attached are visible. In the background the speed ring can be seen, and inside the "bulb," the spider and the rotor

Operating Experience

Mechanical adjustments to the set were carried out by operating it with the sea gates and the basin gate closed and with no water in the tube. The set then operated as a very large fan. It was then possible to measure the following : bearing heating ; out-of-true running of the shaft, i.e. the shaft's motion with respect to the bearings ; starting, slowing down and breaking torques.

Vibrations and distortion of the whole set were also checked so as to obviate having to make any adjustments when the set was first operated under water. Changes in operating conditions were not accompanied by noise or vibration. The efficiency of the set was measured by the Electricité de France Test Department.

The following maximum efficiencies were measured : Direct turbine operation, 90 per cent ; Inverse turbine operation, 70 per cent ; Direct pump operation, 65 per cent ; Inverse pump operation, 70 per cent.

For efficiency computations the head was taken as the difference between the upstream and downstream levels no allowance being made for velocity head.

The Beaumont-Monteux Set

The bulb set at Beaumont-Monteux is similar to the St. Malo set, though simpler in its construction and function, since it has merely two modes of operation—as a turbine and as a spillway sluice. It is shown in the drawing on page 186. It was built before the St. Malo set, which thus incorporates much of the experience gained with it, and its design and completion were fairly clearly a necessary step in the evolution of the more complicated tidal set. It is pointed out, however, that the two sets do not represent different stages of evolution of the "bulb" concept, but are prototypes for its two principal applications, namely tidal and low head schemes respectively. The advantage of the latter application (which again is limited to power stations where frequency regulation is not needed) is largely an economy in the civil engineering works for the power station, where a gain of about 35 per cent in constructional costs is claimed.

The Beaumont-Monteux set has been in use since December, 1958. It was installed in a lock which has never actually been used for navigation and was constructed with the Beaumont-Monteux power station, a run-of-river station on the lower Isère, which has been in operation since the 1920s.

The bulb is carried by the fixed guide vanes towards the downstream, and by three streamlined arms at the upstream, the upper of which comprises the access shaft and carries all the cables and pipes. The two lower arms also serve to circulate air for cooling the alternator, which, in this case has plant outside the bulb for cooling and pumping the air. The drawing clearly shows the bolts on the downstream side of these three arms ; this joint is unbolted, and the steel lining elements around the runner and on top of the culvert are removed to free the "monobloc" when it has to be lifted out for maintenance. This is a fairly simple and speedy operation. The "monobloc" is hoisted by the crane, then turned through 90 deg. and stood vertically, on its end, on the servicing floor above. Those parts of the culvert-lining which are not affected by removal of the bulb, are cast into the surrounding concrete. This was done to give a certain rigidity to the bulb, and to ensure that it was accurately positioned, aims which appear to have been achieved more elegantly in the St. Malo set by using the four prestressed struts.

The upstream "ogee"—the profile of which was determined from a careful study—contains an oil reservoir, and cooling surfaces on the exterior of the "bulb" for cooling the lubricating oil system.

The runner is overhung, and the shaft has two self-aligning bearings. The thrust bearing is, however, simpler than the St. Malo, since only uni-directional thrust is experienced. Other constructional details are generally similar to the St. Malo set. Excitation of the alternator and the governing and safety devices are all mounted in the power house, servicing the bulb through the various cables and pipes.

Table II—*The Beaumont-Monteux Bulb Set*

Nominal output	8800kW	
Head available	9·85m to 12·48m	
Mean flow	90 cumecs	
Corresponding nominal figures for :	Maximum	Minimum
Head	12·48m	9·85m
Flow	79·7 cumecs	91 cumecs
Output	8850kW	7600kW
Diameter of runner	3·8m	
Normal operating speed	150 r.p.m.	
Weight of the "bulb" as dismantled	170 tonnes	
Operation as sluice ; The set has only been operated as a sluice with a head of 12m (i.e. approximately the maximum head) when discharge is as much as 60 cumecs with the set running at 165 r.p.m. (i.e. slightly higher than the synchronous speed)		
Maximum efficiency obtained	91 per cent	
Head corresponding to maximum efficiency	10·3m	

Design and Construction

The Beaumont-Monteux and St. Malo "bulb" sets described in detail here and shown in the drawings accompanying this article have both been designed and manufactured by Etablissements Neyrpic of Grenoble, with alternators made by Société Alsthom of Paris. The development programme was undertaken by Electricité de France who formed an organisation especially to study tidal power some years ago. Construction of the Rance scheme is in the hands of E.d.F.'s Region d'Equipement Hydraulique No. 8 whose headquarters is in Paris.

CONTINENTAL AFFAIRS *(Continued)*

Mont Blanc Tunnel

EXCAVATION of the 11600m long Mont Blanc road tunnel is rapidly approaching the half-way mark. On January 6, at the end of two years' work, the Italian team had achieved 2530m. By January 25, the Italians had reached the 2612m mark, and the French the 2812m mark. Excavation is at present proceeding on both sides in full section of 75 to 85 square metres.

Excavation on the French site began on April 15, 1959. Since the third week of January, 1960, a rail-mounted drilling jumbo is being used (Fig. 1) and removal of rock debris is carried out by means of mine cars hauled by battery-driven locomotives (Fig. 2). In a recent article (see our issues for September 16, 1960, page 478, and September 23, page 15) we described the construction of the tunnel. An illustration of the drilling jumbo appeared in our issue for January 6 (Plate 5). The French contractor, Société A. Borie, has undertaken to excavate 4850m of tunnel in thirty months (i.e. by October 15 of this year) with a possibility of extending this to 5800m to be achieved by February 15, 1962.

The French team was favoured by meeting almost from the beginning with hard and solid rock, the outlook for the Italians was less favourable, inasmuch as the geological survey had indicated the existence for a considerable distance of brittle Liassic calcarious schists. These were, in fact, encountered as far as the 1304m mark, after which the tunnel entered pseudo-stratified granite. The brittleness of the rock led to the adoption of more flexible methods of working, in particular the choice of track-mounted shovels and pneumatically-tyred dumpers for the mucking-out. Work was hampered quite early on by a strong influx of water, and was interrupted more seriously by two heavy falls of rock, one at 501m, the other at 800m from the adit. It was then decided to drive a pilot tunnel and subsequently to enlarge the section, first over the top half, and finally to full size. In the granite which was encountered after the friable strata had been traversed, another serious danger and cause of delay were the severe rock bursts caused by the release of locked-up stresses. These necessitated the employment on a lavish scale of roof-bolting and protective wire mesh netting. It is only recently that the contractor, Società Italiana per Condotte d'Acqua p.A., was able to resume excavation over the full section.

Valve Voltmeter

We have received details of the "RV11" valve voltmeter which is being put on the market by Grundig Radio-Werke G.m.b.H., Fürth (Bavaria). The instrument is characterised by small overall dimensions (220mm by 155mm by 115mm) and low weight (approximately 2·2 kg) and is therefore considered eminently suitable for the service engineer. It permits the measurement of d.c. voltages up to 1000V in seven ranges and, with an additional 1 : 30 voltage divider up to 30kV, with an accuracy of ±3 per cent. Moreover, it is stated to be possible to measure a.c. voltages of 0–1000V, 40 c/s to 8 Mc/s, in seven ranges with an accuracy of ±5 per cent; resistance measurements by means of a directly reading scale cover the interval of 1 ohm to 200 megohm, also in seven ranges. An input resistance of 10 megohm enables measurements to be carried out practically without losses.

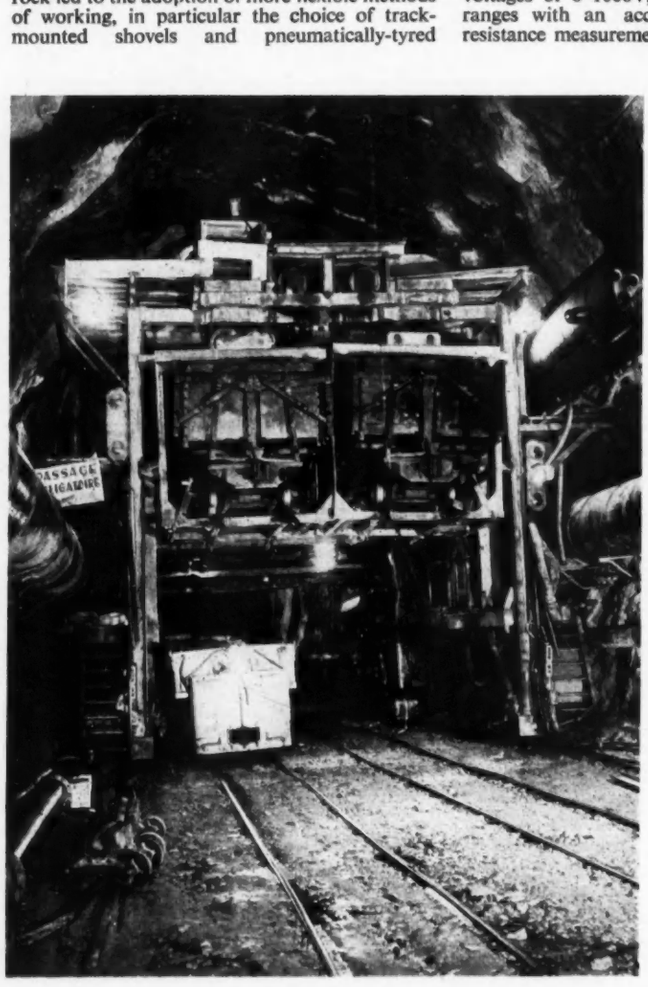
Modernisation of Bougie Airport

Bougie, the principal oil port of Algeria, will soon have available a class "C" airport capable of handling modern aircraft of up to 20 tonnes, such as the blown-wing Breguet and the "Super-Broussard." Construction comprises a runway 1700m long by 40m wide in a grass area of 1900m by 300m. The runway is to be connected by a taxiway to a parking area 175m by 72·5m where later on the terminal and ancillary buildings will be erected. The work entails the diversion over a length of 3·5km of the Setif–Djidjeli main road, and the construction of dykes and flood channels to provide protection from two streams, the Wadi Soumman and the Wadi Acif (or Amane). Earth movements total 300,000 cubic metres, of which 25,000 cubic metres was in connection with flood protection. Some 100,000 square metres of black top surface is being put down.

European Coal Production in 1960

Community coal production in 1960 is estimated to reach a total of 234·5 million tons compared with 234·9 million tons in 1959. Figures for individual countries are as follows:

	1960 Million tons	1959 Million tons	Difference Percentage
Federal Republic of Germany	142·4	141·8	+0·4
Belgium	22·9	22·8	+0·4
France	56·0	57·6	−2·7
Italy	0·7	0·7	—
Netherlands... ...	12·5	12·0	+4·1
Total E.C.S.C. production	234·5	234·9	−0·17



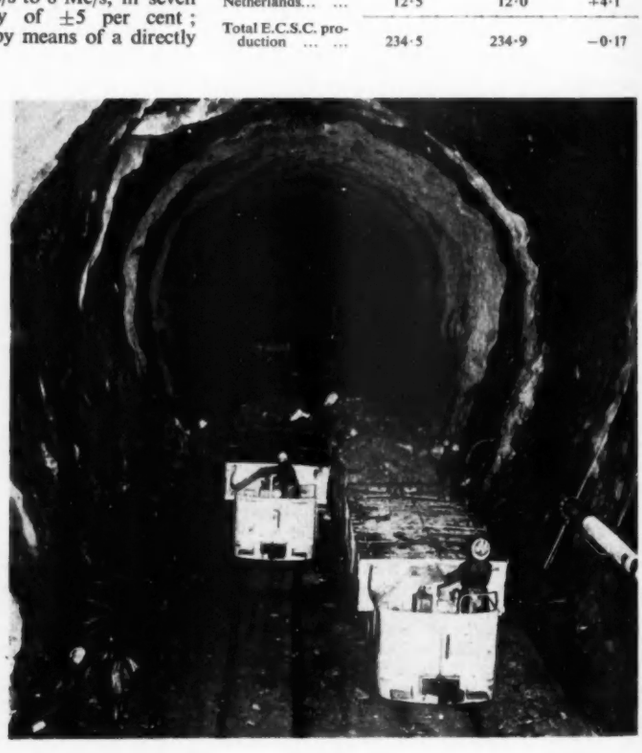


Fig. 1 (Left)—Drilling jumbo used in the French section of the Mont Blanc tunnel. The view is towards the working face. By means of the "cherry-picker" device, empty mine cars are lifted in order to allow filled cars to be shunted away from the face. Fig. 2 (Above)—Working face in French section during "mucking-out." Two trains of mine cars on parallel tracks are being loaded by rail-mounted power shovels

THE AMERICAN SCENE

By Our American Editor

Simplified Control for Vertical Turret Lathes

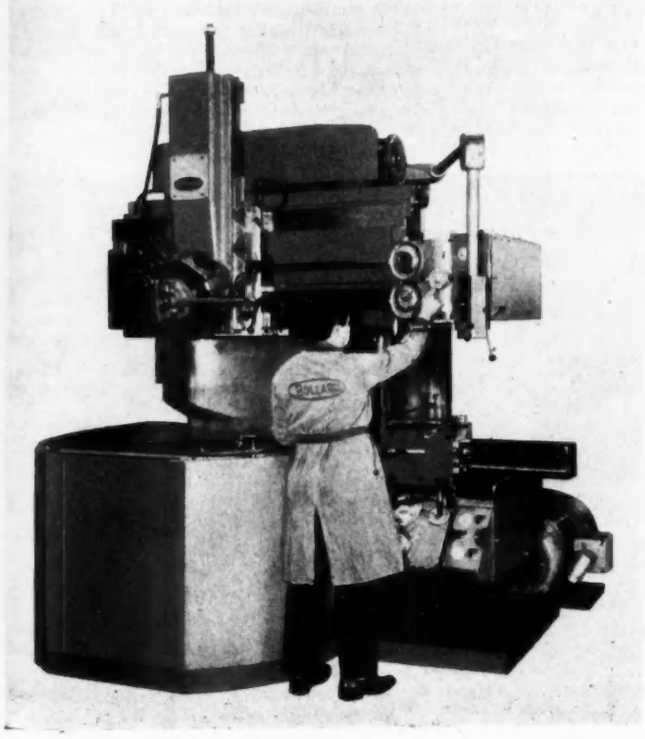
THE Bullard Company, of Bridgeport, Connecticut, recently introduced its new " Dynatrol " vertical turret lathes. These machines incorporate two important advances in machine tool design that make for greater production efficiency by keeping the tool in the cut more of the time and by increasing the operating speed and production rate. The first of these is a new single-lever control for positioning each of the heads and engaging or disengaging the tools from the work. This control shortens the non-productive portion of the operating cycle and results in far more time being spent actually cutting. The second improvement is the use of infinitely variable feeds throughout the full range of the machine instead of conventional step-by-step rates. This design permits the equipment to be run at all times at the optimum feed rate for the kind of material and tool in use. The feed rates can be varied while cutting, too, without stopping the table, allowing changes to be made to match changes in stock removal conditions or to adjust for tool wear.

In keeping with to-day's demands for a higher degree of automatic control in production machinery, all these lathes are now being equipped as a standard feature with " Size-Au-Trol," another new concept developed by Bullard. Functioning like a silent sentinel, this precision size-control device brings the cutting heads automatically to a stop when they reach preset positions during each successive stage of the machining operation. " Size-Au-Trol " thus relieves the operator of all responsibility for sizing the work, eliminates frequent and time-consuming manual gauging operations, reduces time between cuts, and makes it possible to use less-highly-trained operators. For those users who desire complete automation, the machines can also be fitted with the " Man-Au-Trol " system, or with point-to-point or continuous-path numerical control systems. The new " Dynatrol " lathes are available with table diameters ranging from 26in. up to 144in.

The single-lever control system for positioning each of the heads and for engaging or disengaging the tools is a radical departure from the conventional handwheel and toggle-lever systems previously used. It is designed to make the operator truly the master of his machine, placing in his hands in the most simplified form all of the controls for starting and stopping the table, traversing the heads, and engaging the cutting tools. With the new single-lever control system and its visual indicators, the operator can move the heads to the proper position faster and with more confidence, can put the cutting tool closer to the work before engaging the feed, and can set the table in motion smoothly, from one floor-position and with greater ease and flexibility. In the smaller sizes, the control consists of a lever control arm with a conveniently shaped hand grip. Turning the grip changes the direction of movement of the head. Pointing the grip to the left will traverse the head to the left ; pointing it to the right will traverse the head to the right ; turning it upward, or downward, or at a 45 deg. angle, will traverse the head in the indicated direction. With the grip pointed in the direction of traverse desired, the arm is swung to the left to actuate the head-traverse. The head can be traversed at an infinitely variable rate from 0 to 9ft per minute. The traverse rate is varied according to the distance the lever is moved from the neutral position. When the head has been brought close to the work by the traverse motion, the feed is engaged by swinging the arm all the way to the right.

For the larger-sized machines, a remote control system is provided, which is based on the same operating principle. A control pendant is provided from which the operator can regulate table movement, start, stop or inching and select table speed. The speed selected is visually indicated by a light at the appropriate position around a circular dial mounted at the right-hand end of the cross rail. In addition, the heads are operated by a compact, lightweight, portable control box that fits into the operator's palm. On this control box are a push button for starting or stopping the table and four more buttons which permit the operator to select the direction of traverse of that head. There is also a single lever which traverses the head when moved to the left or engages the feed for the head when moved to the right. By moving this single lever to the left, the operator can traverse the head at any one of four traverse rates—9ft per minute, 4ft per minute, 1in per minute, and inching rate—according to the distance the lever is moved from the neutral position. The direction of traverse is regulated by pressing the appropriate directional button, corresponding to up, down, right, or left. Pressing two adjoining buttons simultaneously produces head movement at 45 deg.

In all sizes of the " Dynatrol," the firm offers for the first time infinitely variable feed rates



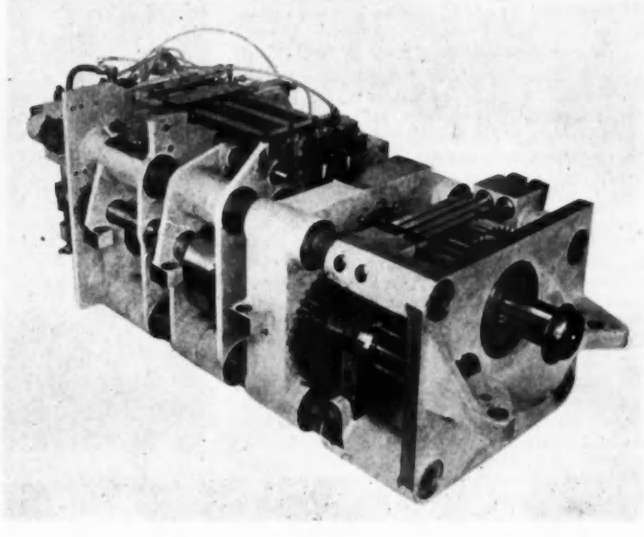


Fig. 1 (Left)—Bullard " Dynatrol " 46in vertical turret lathe with single-lever control. Fig. 2 (Below)—Bullard "V.S." infinitely variable speed 50 h.p. drive of mechanical-hydraulic composition

THE AMERICAN SCENE *(continued)*

rather than the conventional step-by-step feeds. The feed-rate is indicated on a direct-reading dial. The rate of feed can be changed at any time during a cut without stopping the table merely by rotating the feed-rate selector dial. This allows the feed-rate to be matched exactly to the nature of the work and the type of tool, and to be adjusted while cutting to accommodate a change in stock-removal requirements or to allow for tool-wear.

By building precision size-control into the vertical turret lathe, Bullard has made it possible for users to make effective use of less-highly-trained operators. The "Size-Au-Trol" provides precise control over both horizontal and vertical motions of the heads to a degree never before obtainable. The new size-control can be applied effectively to regulate internal boring as well as external turning, and to control both internal and external facing. It is especially advantageous in machining blind holes, which are extremely difficult to reach for precise gauging purposes. The control operates by means of a system of electro-mechanical devices that provides a positive linkage between the control system and the rapid traverse and feed drive to the turret and other cutting heads. This system makes use of rotating drums which are made up of adjustable discs, one for each positioning function. These discs provide the means for making contact with a series of corresponding switches which operate a solenoid valve to engage or disengage the clutches that apply power to the horizontal and vertical feed screws.

A separate "Size-Au-Trol" unit is provided for each head. Each unit is contained in a compact housing that is mounted directly on the feed bracket. The unit contains four horizontal drums, arranged in two pairs mounted one above the other. One pair of drums controls the horizontal motions; the other the vertical. Each pair consists of a coarse and a fine detector drum. The fine detector drums are geared directly to the respective feed screws; the coarse detector drum in each pair is driven from its respective fine drum through worm gearing. Each drum carries a number of detector discs; twenty on each drum is standard, but more can be added, up to a total of forty per drum. These discs are simple flat circular plates, each with a single cam which makes contact with the matching switch as the drum rotates. The exact position of the cam on each disc with respect to the perimeter of the drum can be adjusted easily by rotating the disc. The discs are spring-loaded and are firmly held by friction in the position to which they are set.

On the front of the unit are two selector switches which have two positions: "index" and "repeat." There are also two function indicator dials which are numbered to correspond with the numbers of the detector discs. One revolution of the fine drum corresponds to 1in of head travel; one revolution of the coarse drum corresponds to 100in of head travel. A release push-button on the cover—which is used only after the drum has been set up and when the selector switch is in the "repeat" position—engages the directional clutches, which are otherwise inactivated.

To establish the exact position at which each motion will be completed, the operator first rotates both function indicator dials to the No. 1 position and turns the selector switch to "repeat." He then moves the cutting head in one direction by means of the single-lever control and stops it manually at the desired position of the cutting tool with respect to the work. Next, he sets the No. 1 disc on the coarse drum so that the cam is in contact with the respective switch. He then rotates the No. 1 disc on the fine drum until a neon indicator light, normally on, goes out. He then depresses the push button and traverses the head manually away from the work. To check that the position of the two discs has been correctly set, he manually sets the head in motion and allows "Size-Au-Trol" to bring it to a stop. The position at which it stops is indicated by the reading of the dial pointers on the feed bracket. He now moves the function indicator dial to the next number, indexing the drums to the next position, and repeats the same procedure to set the discs for the next function. This procedure is continued until all the machining functions involved have been set up.

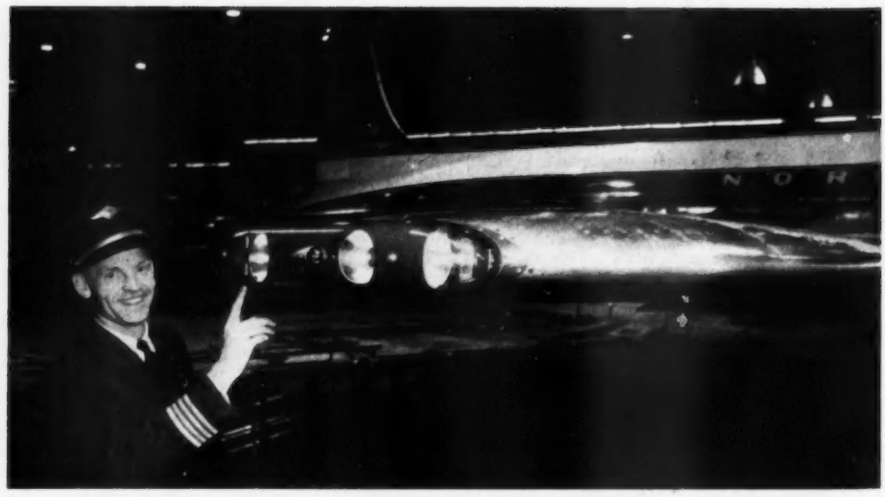
After completing the set-up, the operator resets the function indicator dials to the No. 1 position, turns the selector switches from "repeat" to "index," and is ready to start machining. The movements of the heads are engaged manually in the proper direction by means of the single-lever control. When the head reaches the preset position, the control stops its movement automatically. A stepping relay indexes the drum to the next function and the operator then manually engages the proper traverse or feed for the next movement of the head. To compensate for tool wear, provision is made for the operator to over-ride the control in order to make manual adjustments in the size of the work before engaging the next function.

An unusual infinitely variable speed drive is also now available to power the firm's lathes. Fundamentally, the Bullard "V.S." Drive is a completely mechanical-hydraulic means of obtaining from a constant-speed motor a positive drive with selective and adjustable infinitely variable speeds, without steps or interruptions, at constant horsepower over a required speed range and then at constant torque to zero speed, using a combination of planetary gearing, controllable hydraulic feed-back and shiftable square-toothed clutches. An automatic timely selection of the clutches through an integrated control device ensures the proper combination of internal speed ranges to provide the desired output speed. The first production model of the new drive is a 50 h.p. unit which is being applied to the new 46in lathe. This drive has been designed to run at a constant input speed of 1800 r.p.m. delivering constant horsepower at any output speed from 112 to 1550 r.p.m. and constant torque from zero to 112 r.p.m. The table speed is infinitely adjustable, throughout the entire range, without steps or interruptions, and can be increased or decreased without stopping the table and under full load, so that the workpiece may be machined at the most efficient and effective speed using the latest cutting tools and allowing for variations in part configuration.

The 13½ to 1 constant horsepower range of speed variation is considerably greater than that offered by other mechanical or electronic speed variators, which generally offer only a 3 to 1 or 4 to 1 range. Speed variation is very simply controlled by means of a single dial with a pointer and an accompanying calibrated r.p.m. scale mounted on the pendant at the operator's position in front of the machine. It is, therefore, only necessary for the operator to dial the desired table speed, which is then automatically provided through the integrated control device in the drive. A built-in safety device to prevent damage to both the variable speed mechanism and other parts of the machine is provided to function at 25 per cent overload. This device disengages the main clutch and applies the brake, stopping the machine much faster than the operator could act manually. With the new drive the maximum rate of shifting through the complete range is considerably faster than the rate of speed variation possible with the standard stepped-speed headstock. It is possible to bring the work gradually to a full stop with the tool in the cut and then accelerate to original full speed again in a matter of seconds without damage to the tool or any shock to the drive. To take cuts at constant surface feed and speed with constant horsepower is easily achieved with the drive because of its inherent characteristics of constant horsepower, infinitely variable speeds, wide ratio of speed variation and positive efficient drive.

Collision Warning Light

A refined form of light to increase the ease with which aircraft may be observed was introduced last year, initially in the fleet of Northwest Airlines Inc., one of whose pilots, Mr. W. Atkins, invented it—our illustration shows the inventor with the prototype equipment. The Honeywell-Atkins Anti-Collision Light employs flashing lights with an intensity of about $\frac{1}{2} \times 10^6$ lumens and a flash duration of about 10^{-3} seconds. The use of intermittent flashing gives many significant advantages over the accepted rotating anti-collision light; it cannot induce vertigo in the aircraft crew, the flash is too brief to form a latent image on the retina of the observer (so that there is no interference with night vision), the aspect can be different in different directions (currently 160 flashes per minute in the ahead sector, eighty flashes per minute on the beam, and forty flashes per minute astern), and there is a great economy of electricity (a set consuming 300W has been visible for over 100 miles on a clear night and 5 miles in bright sunlight). The illustration shows that there are separate sources and reflectors for the lights in each direction, thus eliminating all moving parts. Installations are being developed in Great Britain by Honeywell Controls, Ltd.



Prototype of flashing warning light seen on wing tip of DC-7C; notice the large size of the light sources compared to the normal navigation light

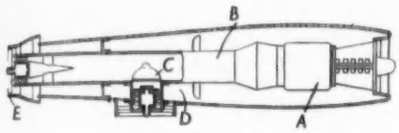
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

AIRCRAFT

857,037. July 9, 1959.—POWER UNIT, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor : Roland Michael Fitzgerald.*)

The invention relates to an improved power unit adapted to provide vertical and/or horizontal thrust for an aircraft. There is provided a gas turbine engine, two turbo-fan units, one of which is positioned to provide vertical thrust and the other to provide forward propulsive thrust. Ducting interconnects the gas turbine and the turbo-fan units, and a valve in the ducting enables at least part of the output of the gas turbine to be applied to either fan turbine unit at will. Preferably the engine and the two fan turbine units, together with the ducts and the valve are mounted in a single nacelle. The propulsion unit shown comprises a nacelle within which is housed a conventional jet propulsion engine *A*, having an air intake and an exhaust outlet duct *B*. This duct contains valve *C* by which the exhaust



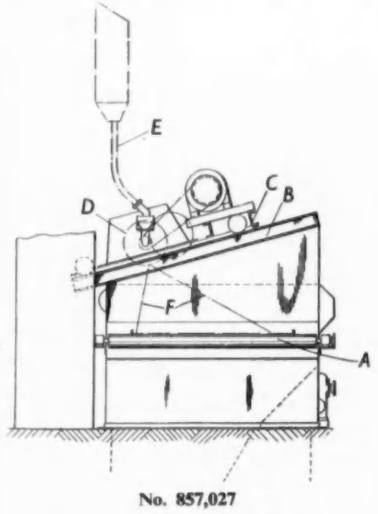
No. 857,037

gases can be diverted to the turbine of a vertical turbo-fan unit *D*, or to a forward propulsive thrust turbo-fan *E*. When the valve is in the position shown the output of the gas turbine passes through guide vanes into the turbo-fan *E*. When the valve is in the raised position the entry to the turbine of the forward propulsion unit is closed and the entry to the turbine of the vertical propulsion turbo-fan *D* opened. Air for the fan for vertical thrust is taken in through side louvres on the nacelle.—*December* 29, 1960.

SHEET METALWORKING MACHINES

857,027. April, 18 1958.—BENDING OF METAL PANELS, Tilghman's, Ltd., Broadheath, near Manchester. (*Inventor : John Carle.*)

This invention relates to a method and apparatus for the bending of aircraft wing and other metal panels. The panel to be shaped is passed on a conveyor below an impeller wheel which throws shot at the panel and by a peening action causes it to bow towards the wheel. By the positioning and angling of



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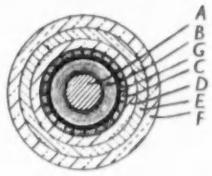
the wheel, the extent of bending of the panel may be varied over its width and by this means the panels may, for example, be bent to conform to aerofoil shapes. Referring to the accompanying drawing, the machine shown comprises a roller conveyor *A* having mounted transversely above it two sloping girders *B* which form a track on which a carriage *C* may be moved. The carriage carries an impeller wheel *D* with its drive. Means (not shown) are provided for adjusting the position of the carriage on the track and the transverse position of the wheel in relation to the conveyor. Shot fed to the wheel by a flexible pipe *E* from a hopper and thrown at a panel passing along the conveyor imparts the peening action to cause the panel to bow towards the wheel. The shot is thrown over a limited angle, say, 75 deg., as indicated by the broken lines *F*, and to obtain the desired aerofoil shape the wheel is positioned to one side of the centre of the conveyor and the wheel assembly is tilted on the girders about the axis of the wheel so that the angle over which the shot is thrown covers the width of the panel or that part of the width which requires to be shaped. By this arrangement, the part of the panel which is struck by shot travelling at right angles to the panel suffers the greatest degree of peening and therefore bows the most. The parts of the panel either side of this part receive gradually less and less peening due to the increasing distance of travel, and the reducing angle of strike, of the shot. In this way the varied curvature of an aerofoil section is given to the panel. To remove any local defects which may occur in the desired shape, a spotting-up nozzle at the end of the machine projects the shot in jet form and is provided with a traverse arrangement so that the jet may be directed at any desired local area on the panel. The speed of the impeller wheel may be changed to vary the degree of peening and the extent of shaping of the panel. If desired the wheel speed may be varied over a range of speeds according to a given law as a panel is passing below the wheel to vary the panel shape along its length. Alternatively or additionally, the speed of travel of the panel on the conveyor may be varied as the panel passes below the wheel—*December* 29, 1960.

ELECTRICAL ENGINEERING

857,548. September 13, 1957.—DIRECT CURRENT HIGH-VOLTAGE CABLES, Siemens-Schuckertwerke Aktiengesellschaft, Berlin and Erlangen, Germany.

It has already been proposed to provide cables for the transmission of high-voltage direct current in which the negative core is surrounded concentrically by the positive core, so that the latter to some extent protects the negative core against absorption of moisture. In the arrangement according to this invention (see drawing) the inner conductor *A*, which



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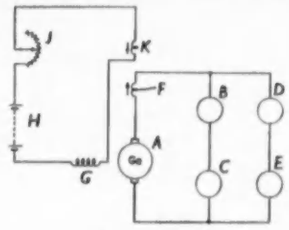
forms the negative core, is provided with an insulation *B* constructed of electrically high-grade, but water-sensitive, insulating material. Over this is concentrically applied the outer conductor *C* forming the positive core. This in turn is surrounded by an insulating layer *D*, for example of polyethylene, which has a high water resistance. Over this lies a sheathing *E* of greater mechanical strength than the material of the layer *D*, consisting of a mixture having a high degree of water impermeability and based on isobutylene or butyl rubber having a high carbon black content, which may be protected by a further protective sheathing *F* of high mechanical strength, for example based on polyvinyl chloride. If the insulation *B* of the inner negative core is constructed of fibrous materials, more especially paper tapes, impregnated with more or less viscous oil resin masses, as in the illustrated example, it is desirable to apply over this insulation, below the concentric conductor *C*, an oil-impermeable protective layer *G*, which may, for example, be formed of a metal foil or of a suitable oil-proof plastic foil wound spirally on to the cable.—*December* 29, 1960

DIESEL-ELECTRIC TRACTION

857,034. June 6, 1958.—DIRECT CURRENT ELECTRIC GENERATORS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors : Robin Howard Salis Simon and Reginald Donahoe Ball.*)

This invention relates to d.c. electric generators of the kind having a separately excited main field winding and a series interpole winding. An object of the invention is to improve the commutating conditions of such a generator over a wide range of load currents. For this purpose the generator has an additional separately excited winding on the interpoles which is excited in such a manner that, over a predetermined range of generator load current, the net interpole excitation increases with increase of generator load current to a greater extent than it would due to the series interpole winding alone, and vice versa. The invention is described in relation to a diesel-electric locomotive power circuit with a torque regulator controlled by the engine governor and arranged automatically to vary the excitation of the main field winding in a sense to maintain substantially constant generator output power. Referring to the drawing, the main generator *A* is driven by a



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diesel engine (not shown) and its armature supplies four traction motors, *B* to *E* respectively, via a series interpole winding *F*. The main field winding *G* of the generator is supplied from a substantially constant voltage d.c. source, indicated by the battery *H*, via a torque regulator *J*. The main winding is supplied through a circuit which includes a compound winding *K* on the generator interpoles which, as shown by the arrows, opposes the series interpole winding *F*. In this form of excitation control, the excitation of the generator due to the main field winding is reduced automatically by the torque regulator as the load current increases. By the inclusion of the compound interpole winding in series with the main field winding, therefore, the opposing interpole ampere turns will be automatically reduced as the generator load current increases. The interpole excitation required for optimum commutating conditions is not directly proportional to the load current but, on account of saturation of the magnetic materials and distortion of the magnetic field, varies with load current according to a more complicated law. Thus, for optimum commutating conditions, it is necessary for the compound interpole winding to provide the difference in magneto-motive force between that provided by the series interpole winding (which varies directly with armature current) and that required for best commutation. By suitable choice of air gaps and turns ratio, the difference in magneto-motive force can be made to fit approximately the main field current characteristic produced by the automatic torque regulator. The impedance of the compound interpole winding circuit is high (due to the main field winding being in series) thus making the damping action of the compound winding on changes in load current small. It will also be noted that the torque regulator produces a given main field current independent of field resistance, so that the compensation is not affected by temperature changes in the main field winding. In an alternative arrangement the winding *K* is supplied from a separate constant voltage source.—*December* 29, 1960.

TOOLS

856,047. January 9, 1958.—DIAMOND TOOLS, Dagobert William Alfred Fritz Rudorff, 77, Onslow Gardens, London, S.W.7. (*Inventors : Samuel Tolansky and Dagobert William Alfred Fritz Rudorff.*)

This invention relates to tools in which diamonds or diamond particles are wholly or partially embedded in a metallic plastic or vitreous bonding material. To produce tools in which the diamonds are firmly held in the bonding material the diamonds are artificially etched so that at least the part of their surfaces in contact with the bonding material is pitted. In practice the diamonds are immersed in molten potassium nitrate, for example, at 700 deg. Cent. for one hour. Their surfaces will then be found to be completely pitted. The diamonds are then cleaned in boiling water and used in the etched state for normal diamond tool manufacture. In tools where single layers of diamonds are used, only the parts held by the bonding material are etched, leaving the parts protruding.—*December* 14, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb., 3.—LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, " Static Switching Control Systems," J. N. Fletcher, 7.30 p.m. ★ STOKE AND CREWE BRANCH : Royal Hotel, Crewe, " Electrical Catering Equipment," H. Meadowcroft, 7.30 p.m.

Sat., Feb. 4.—MANCHESTER BRANCH : Engineers Club, Albert Square, Manchester, " Heavy Industrial Control Gear," C. V. Curran, 7.15 p.m.

Mon., Feb. 6.—BOLTON BRANCH : Railway Hotel, Trinity Street, Bolton, " Control Instruments," 7.45 p.m. ★ ESSEX BRANCH : Angel Hotel, Broadway, Ilford, Essex, " Automatic Control," W. L. Stern, 8.15 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, " Instrument Aids in Obtaining Higher Boiler Efficiency," J. W. Nixon, 7.30 p.m. ★ SHEFFIELD BRANCH : Royal Victoria Hotel, Sheffield, Film, "A Tour Round Britain," F. E. Price, 7.30 p.m.

Tues., Feb. 7.—LEICESTER BRANCH : Westcotes Constitutional Club, Wilberforce Road, Leicester, " Control Centres for Modern Industry," H. B. Davies, 7.30 p.m. ★ WEST LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, London, W.6, films, 7.45 p.m. ★ READING AND DISTRICTS BRANCH : " Marquis of Lorne," Friar Street, Reading, " Refrigeration," 7.30 p.m.

Wed., Feb. 8.—BIRMINGHAM BRANCH : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, " Panelec Floor Warming and Ancillary Equipment," K. W. Ballamy, 7.30 p.m. ★ LUTON BRANCH : College of Technology, Park Square, Luton, " Variable Speed a.c. Motors," J. C. Bone, 8.15 p.m.

Thurs., Feb. 9.—BRADFORD AND DISTRICT BRANCH : Midland Hotel, Bradford, " Further Developments in Metal Rectifiers," D. Magnall, 7.30 p.m. ★ SOUTH WEST LONDON BRANCH : Prince of Wales Hotel, London, S.W.19, " Progress in Sound Recording," G. M. Nathan, 7.45 p.m. ★ OXFORD AND DISTRICTS BRANCH : Reactor School, A.E.R.E., Harwell, " Electric Motor Control Gear," R. F. Mathieson, 5.45 p.m.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Fri., Feb. 10.—WEST MIDLANDS AREA COMMITTEE : College Theatre, Coventry Technical College, The Butts, Coventry, " The Development of Science and Technology in the Future," Sir John Cockcroft, 7 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Feb. 7.—LONDON SECTION : Institute of Physics, 47, Belgrave Square, London, S.W.1., Joint meeting with the Electronics Group of the Institute of Physics, " Tunnel Diodes," 2.15 p.m.

Wed., Feb. 8.—COMPUTER GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, " Perseus, a Medium-scale Data Processing System," G. Emery, 5.30 p.m. ★ SOUTH WALES SECTION : Welsh College of Advanced Technology, Cardiff, " The Principles of Analogue to Digital Computer Conversion," J. L. W. Churchill, 6.30 p.m. ★ SCOTTISH SECTION : Department of Natural Philosophy, The University, Drummond Street, Edinburgh, " Measuring Stability and Spurious Modulation Spectra of High Quality Oscillators," A. L. Whitwell, 7 p.m. ★ WEST MIDLANDS SECTION : College of Technology, Wulfruna Street, Wolverhampton, " Computers and Mathematics," R. Wooldridge, 6.15 p.m.

Thurs., Feb. 9.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, " Measuring Stability and Spurious Modulation Spectra of High Quality Oscillators," A. L. Whitwell, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Feb. 7.—NORTHERN REGION : George Hotel, Huddersfield, Discussion on " Planned Plant Maintenance," 2.30 p.m.

Wed., Feb. 8.—SCOTTISH REGION : Royal Hotel, 5, Union Street, Dundee, Discussions on " Scheduled Maintenance of Boiler Plant and Auxiliaries," opened by L. M. Kenneth, 10.30 a.m., and " Performance and Cost Control," opened by C. W. Scott, 2 p.m.

COVENTRY ENGINEERING SOCIETY

Thurs., Feb. 9.—Social Club, Coventry Victor Motor Company, Ltd., Ford Street, Coventry, " History and Development of Dry Bearings," P. G. Forrester, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., Feb. 9.—MANCHESTER CENTRE : Demonstration Theatre, North Western Electricity Board, Town Hall Extension, Manchester, 2, " Floodlighting of Liverpool Cathedral," C. C. Smith, 6 p.m.

Mon., Feb. 13.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, Presidential Address, W. S. Stiles, 6.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Feb. 9.—BEDS. AND HERTS. SECTION : W. H. Allen, Sons and Co., Ltd., Bedford, " Effect of Mould Materials on the Cooling Rate and Physical Properties of Cast Metals (Sub-Committee Report, T.S. 46)," J. Hird, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 6.—MERSEYSIDE AND NORTH WESTERN SECTION : Liverpool Engineering Society, The Temple, Dale Street, Liverpool, Annual General Meeting, and " Details and Operating Data of Recent a.c. Installations," A. N. Savage, 6 p.m. ★ STUDENT LECTURE : Memorial Building, 76, Mark Lane, London, E.C.3, " The Marine Steam Turbine," D. M. V. Parkinson, 6.30 p.m.

INSTITUTE OF METALS

Tues., Feb. 7.—SOUTH WALES LOCAL SECTION : Metallurgy Department, University College, Singleton Park, Swansea, " Inspection of the High Strength Wrought Aluminium Alloys," W. Smitham, 6.30 p.m.

Wed., Feb. 8.—MANCHESTER METALLURGICAL SOCIETY : Manchester Literary and Philosophical Society, George Street, Manchester, " Residual Stress and Stress Relieving," L. E. Benson, 6.30 p.m.

Thurs., Feb. 9.—EAST MIDLANDS METALLURGICAL SOCIETY : Derby and District College of Art, Derby, " The Modern Production and Metallurgy of Blackheart Malleable Cast Iron," H. Greatorex, 7.30 p.m. ★ LIVERPOOL METALLURGICAL SOCIETY : Department of Metallurgy, The University, Liverpool, " The Origin and Solution of Some Industrial Corrosion Problems," E. C. Campbell, 7 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Feb. 6.—SCOTTISH CENTRE : Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, " Recent Developments in Head Lighting," J. H. Nelson, 7 p.m.

Tues., Feb. 7.—EASTERN CENTRE : The Canteen, Eastern Counties Omnibus Company, Ltd., Norwich, " Modern Trends in Paint Manufacture and Application," E. J. Robins, 7.30 p.m. ★ SOUTH WESTERN GROUP : Duke of Cornwall Hotel, Plymouth, " The Design of Radial-Flow Turbochargers and their Application to Road Transport," E. Kellett, 7.30 p.m.

Wed., Feb. 8.—EAST MIDLANDS CENTRE : Mechanics' Institute, Nottingham, " Vocational Training in the United Kingdom and Overseas," H. S. S. Brown, 7.30 p.m. ★ SOUTHERN CENTRE : Palmeira Hotel, Hove, " Air Suspension," J. Sainsbury, 7.30 p.m.

Mon., Feb. 13.—MANCHESTER AND DISTRICT CENTRE : Stephenson Room, Third Floor, Engineers' Club, Albert Square, Manchester, " Modern Vehicles for the Motorway," A. H. Carter, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Feb. 15.—Geological Society, Burlington House, London, W.1, Hinchley Memorial Lecture, " Science and the Developing Countries," P. M. S. Blackett, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 6.—MERSEY AND NORTH WALES CENTRE : Royal Institution, Colquitt Street, Liverpool, " The Logical Design of Electrical Networks using Linear Programming Methods," U. G. W. Knight, 6.30 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Birmingham, " Development of H.V. Air-Break Circuit-Breakers with Insulated-Steel-Plate Arc Chutes," F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton, 6.30 p.m. ★ SOUTH MIDLAND CENTRE : Winter Gardens, Great Malvern, " Cosmic Thunderstorms," C. E. R. Bruce, 7.30 p.m. ★ MAIDSTONE DISTRICT BRANCH : Technical College, Maidstone, " Road Heating," L. H. Carmalt, 6.30 p.m.

Tues., Feb. 7.—MEASUREMENT AND ELECTRONICS SECTIONS : Savoy Place, London, W.C.2, " Magnetic Properties of Thin Films for Computing Devices," E. M. Bradley, 5.30 p.m. ★ NORTH MIDLAND CENTRE : Leeds and County Conservative Club, South Parade, Leeds, 1, Third Hunter Memorial Lecture, " The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 6.30 p.m. NORTH WESTERN UTILISATION GROUP : Engineers' Club, Albert Square, Manchester, " A Survey of Street Lighting and its Future," W. R. Stevens, and H. M. Ferguson, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE : Carlton Hotel, Edinburgh, " A Visit to South Africa," M. G. Say, 7 p.m. ★ SOUTHERN CENTRE : The University, Southampton, " Stereophonic Transmission and Reproduction," P. M. Thompson, 6.30 p.m. ★ EAST MIDLAND CENTRE : E. M. E. B., Church Croft, Horninglow Street, Burton-on-Trent, " Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott, 6.30 p.m. ★ EAST ANGLIAN SUB-CENTRE : Assembly House, Norwich, Joint Meeting with the East Midland Branch of the Institution of Mechanical Engineers, " The Deltic Locomotive," C. M. Cock, 7.30 p.m.

Wed., Feb. 8.—NORTH WESTERN ELECTRONICS AND COMMUNICATIONS GROUP : Engineers' Club, Albert Square, Manchester, " Microminiaturization," L. J. Ward, 6.15 p.m. ★ NORTH LANCASHIRE SUB-CENTRE : N.W.E.B. Demonstration Theatre, Lancaster Road, Lancaster, " A Survey of Street Lighting and its Future," W. R. Stevens and H. M. Ferguson, 7.30 p.m. SOUTH WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, " Energy Resources of Scotland," J. Henderson and C. L. C. Allan, 6 p.m. ★ OXFORD DISTRICT BRANCH : S.E.B. District Office, 37, George Street, Oxford, " Development of Eurovision," M. J. Pulling, 7 p.m.

Thurs., Feb. 9.—UTILISATION SECTION : Savoy Place, London, W.C.2, " Some Notes on the Electrical Requirements of General Cargo Docks," E. R. Radway, 5.30 p.m. ★ CAMBRIDGE ELECTRONICS AND MEASUREMENT GROUP : Cavendish Laboratory, Cambridge, " The Ultrasonic Microscope," C. N. Smyth, 8 p.m. ★ NORTH SCOTLAND SUB-CENTRE : Electrical Engineering Department, Queen's College, Dundee, " Subscriber Trunk Dialling," D. A. Barron, to be read by H. E. Francis, 7 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE : Conference Room, S.W.E.B., The Kingsway, Swansea, " Discrimination between H. R. C. Fuses," E. Jacks, 5.30 p.m.

Fri., Feb. 10.—NORTH SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, " Subscriber Trunk Dialling," D. A. Barron, to be read by H. E. Francis, 7.30 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : North Staffs. College of Technology, Stoke-on-Trent, " Planning and Installation of the Sound Broadcasting Headquarters for the B.B.C.'s Overseas and European Services," F. Axon, and O. H. Barron, 7 p.m. ★ SOUTHERN CENTRE : S.E.B. Showrooms, Newport, I.O.W., " Thermo-Nuclear Physics," T. E. Allibone, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 14.—39, Elmbank Crescent, Glasgow, " Modern Machine Tools and Production Methods," 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Feb. 6.—NORTH-EAST BRANCH : New Lecture Theatre, Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, 1, " Precision Investment Casting," N. Walker, 7.15 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Feb. 8.—Kent Room, Caxton Hall, Westminster, S.W.1, " Process Steam Utilisation," W. N. Barber, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Feb. 3.—LONDON BRANCH : Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, " Lessons Learned on the Design, Construction and Maintenance of Motorways—(iii) From the Contractor's Angle," W. Kirby Laing, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 3.—SCOTTISH BRANCH : Technical College, Dundee, Repetition of the Graham Clark Lecture, " The Engineer and Civilisation," Sir Hugh Beaver, 7.30 p.m.

Mon., Feb. 6.—NORTH EASTERN BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, Repetition of the Thomas Lowe Gray Lecture, " The Early Developments of the Dracone Flexible Barge," W. R. Hawthorne, 6 p.m.

Tues., Feb. 7.—WESTERN BRANCH : Engineering Laboratories, The University, University Walk, Bristol, " Direct Conversion of Heat to Electricity," P. D. Gunn, 6.30 p.m.

Wed., Feb. 8.—1, Birdcage Walk, Westminster, London, S.W.1, " The Influence of Measuring Force, Stylus Radius and Surface Finish on the Accuracy of Measurement of Work Pieces by a Comparator," L. W. Nickols, and T. R. J. Oakley, and " An Investigation into the Accuracy of Industrial Measurements of Sizes between 0·02in and 5in," P. W. Harrison, 6 p.m. ★ EASTERN GRADUATES' SECTION : Old Manor House, St. Margarets Green, Ipswich, " Batch Production of Agricultural Machinery," J. C. Taylor, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : College of Art, Green Lane, Derby, Film Show, 7.15 p.m. ★ NORTH WESTERN GRADUATES' SECTION : Research Hall, A.E.I.(Manchester) Ltd., Trafford Park, Manchester, " The Numerical Control of Machine Tools," P. G. Wheeldon, 6.30 p.m. ★ NORTH WESTERN GRADUATES' SECTION : Blossoms Hotel, Chester, Technical Film Show, 7 p.m.

Thurs., Feb. 9.—SOUTHERN BRANCH : Sun Hotel, Chatham, Kent, " Materials in the Service of Mechanical Engineers," R. J. Brown, 7.30 p.m. ★ EASTERN GRADUATES' SECTION : Northampton Technical College, St. George's Avenue, Northampton, Film Show, 7.30 p.m. ★ MIDLAND GRADUATES' SECTION : Technical College, Wolverhampton, " Mechanical Handling," J. Challon, 7 p.m. ★ NORTHERN IRELAND GRADUATES' SECTION : Visit to I.C.T. Ltd., Castlereagh, 7 p.m. ★ SOUTHERN GRADUATES' SECTION : Technical College, Brighton, " Free Piston Gas Generators and their Application," A. G. Clarke, 7.15 p.m.

Fri., Feb. 10.—EASTERN GRADUATES' SECTION : College of Further Education, Queen Alexandra Road, High Wycombe, " Mechanical Aspects of Fractional Horsepower Motors," P. G. Edkins, 7.30 p.m.

Sat., Feb. 11.—SOUTHERN GRADUATES' SECTION : Visit to the South Western Stone Company, Ltd., Portland, Dorset, 2.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Feb. 7.—Royal Society of Arts, John Adam Street, Strand, W.C.2, " Standards in Plant Engineering," E. L. Diamond, 7 p.m. ★ PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, " National Dialling Systems," W. E. Gill, 7.30 p.m.

Wed., Feb. 8.—EAST MIDLANDS BRANCH : Sherwood Room, County Hotel, Theatre Square, Nottingham, " Some Problems in the Design of Large Rocket Engine Test Beds," R. H. B. Forester, 7 p.m. ★ LEICESTER BRANCH : The University, Leicester, Fuel Efficiency Forum, 7.30 p.m. ★ WESTERN BRANCH : Grand Hotel, Broad Street, Bristol, " Foundry Development," D. Potts, 7.15 p.m.

Thurs., Feb. 9.—GLASGOW BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, " The Use of Gas in Industry," R. W. Deans, 7.15 p.m. ★ NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, 1, " Thermal Insulation of Factory Buildings," 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 6.—NORTH WESTERN REGION : Reynolds Hall, Manchester College of Science and Technology, Manchester, " Production Engineering Research in the Soviet Union," R. Tilsley, 7.15 p.m.

Tues., Feb. 7.—MIDLANDS REGION : Denbro Ltd., Soho Hill, Handsworth, Birmingham, 19, Works Visit and Lecture " The Production of Farm Tools," D. W. Butchart, 7.15 p.m. ★ NORTHERN REGION : College of Further Education, Cleveland Avenue, Darlington, " A Consultant's Role in Industry," A. Beeton, 7 p.m.

Wed., Feb. 8.—NORTH WESTERN REGION : Accrington College of Further Education, Sandy Lane, Accrington, " Gears," H. R. Stansfield, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 6.—BURTON-ON-TRENT SECTION : Midland Hotel, " Rubber in Astronautics," and Film " Rubber in Space Research," N. H. Longton and W. H. Stevens, 7.30 p.m. ★ NORTH EASTERN SECTION : Eldon Grill, Newcastle, Debate and Brain's Trust, 7 p.m. ★ SOUTH WALES AND MONMOUTHSHIRE SECTION : Queens Hotel, Cardiff, " Motor Car and Motor Cycle Racing," A. T. Walsham, 7.30 p.m.

Wed., Feb. 8.—WEST OF ENGLAND SECTION : Melksham House, Melksham, " How Tyres Wear," A. Schallamach, 8 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 3.—WESTERN COUNTIES BRANCH : Small Lecture Theatre, University Engineering Laboratories, University Walk, Bristol, 8, Forum, 6 p.m. ★ MIDLAND COUNTIES GRADUATES' AND STUDENTS' SECTION : Engineering Centre, Stephenson Place, Birmingham, " Structural Engineering in the Construction of the Inner Ring Road," S. G. Piggot, 6.30 p.m.

Tues., Feb. 7.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, " The Channel Crossing—Bridge or Tunnel," J. F. Pain, 6.15 p.m. ★ NORTHERN IRELAND BRANCH : Civil Engineering Department, David Keir Building, Queen's University, Belfast, " Concrete Bridge Design," L. Clements, 6.30 p.m.

Thurs., Feb. 9.—11, Upper Belgrave Street, London, S.W.1, " Aluminium Strut Design," J. B. Dwight, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 3.—Pepys House, 14, Rochester Row, London, S.W.1, Films, 7 p.m.

Fri., Feb. 10.—Pepys House, 14, Rochester Row, London, S.W.1, " The Detection of Radiation," G. Ballard, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 10.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, " Heavy-Lift Vessel ' Adventurer '," C. Stephenson, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Mon., Feb. 6.—NORTH WESTERN BRANCH : Liverpool Engineering Society, The Temple, 23, Dale Street, Liverpool, " Lift Slab Design and Construction," F. R. Benson, 6.30 p.m.

Tues., Feb. 7.—NORTH WESTERN BRANCH : College of Technology, Sackville Street, Manchester, " Lift Slab Design and Construction," F. R. Benson, 6.45 p.m. ★ MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, " Concrete Construction in Russia," C. V. Blumfield, 6 p.m.

Fri., Feb. 10.—SOUTH WALES AND MONMOUTHSHIRE BRANCH : South Wales Institute of Engineers, Park Place, Cardiff, " Reinforced Concrete Construction in the Coal Industry," C. A. C. Davies, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 7.—ASTRONAUTICS AND GUIDED FLIGHT SECTION : Lecture Theatre, 4, Hamilton Place, London, W.1, " An Appreciation of Missile Structures," A. F. Newell, 6 p.m.

Wed., Feb. 8.—GRADUATES' AND STUDENTS' SECTION : Lecture Theatre, 4, Hamilton Place, London, W.1, " Flight Testing of VTOL Aircraft," T. W. Brooke-Smith, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Feb. 6.—12, Great George Street, Westminster, London, S.W.1, " Share Valuations : Why and How " T. A. Hamilton Baynes, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Mon., Feb. 6.—CANTOR LECTURE : John Adam Street, Adelphi, London, W.C.2, " The Chemical and Plastics Industries," J. Taylor, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, Feb. 3.—ROAD AND BUILDING MATERIALS GROUP : Robinson Theatre, The University, Manchester, " Surface Active Agents in Bituminous Road Materials," D. H. Mathews, 6.30 p.m.

Tues., Feb. 7.—CORROSION GROUP : Engineering Centre, Stephenson Place, Birmingham, Short Papers Evening, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Feb. 6.—Geological Society, Burlington House, London, W.1, Presidential Address, W. E. Humphrey, 5 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Mon., Feb. 6.—DATA PROCESSING SECTION : Manson House, 26, Portland Place, London, W.1, " The Universal Decision Element," J. E. Parton, and A. Rose, 6.30 p.m.

TELEVISION SOCIETY

Fri., Feb. 10.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, "Transistorised Distribution Amplifiers," B. Marsden, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Feb. 8.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, S.W.1, " Space Exploration," L. J. Carter, 7 p.m.